**University of Alberta**

# PLAYER-INFORMED INTERACTIVE STORYTELLING

by

**David James Thue**

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Science**.

Department of Computing Science

Edmonton, Alberta
Fall 2007

Library and Archives Canada

Published Heritage Branch

395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque et Archives Canada

Direction du Patrimoine de l'édition

395, rue Wellington
Ottawa ON K1A 0N4
Canada

*Your file Votre référence*
*ISBN: 978-0-494-33361-7*
*Our file Notre référence*
*ISBN: 978-0-494-33361-7*

NOTICE:
The author has granted a non-exclusive license allowing Library and Archives Canada to reproduce, publish, archive, preserve, conserve, communicate to the public by telecommunication or on the Internet, loan, distribute and sell theses worldwide, for commercial or non-commercial purposes, in microform, paper, electronic and/or any other formats.

The author retains copyright ownership and moral rights in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

AVIS:
L'auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, publier, archiver, sauvegarder, conserver, transmettre au public par télécommunication ou par l'Internet, prêter, distribuer et vendre des thèses partout dans le monde, à des fins commerciales ou autres, sur support microforme, papier, électronique et/ou autres formats.

L'auteur conserve la propriété du droit d'auteur et des droits moraux qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

---

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.

Canada

*When you do enough research, the story almost writes itself.*

– Robert McKee

# Abstract

Storytelling has long been a medium for human entertainment, but over the course of many years, its potential as a form of interaction has slipped into the background. This thesis is an investigation of the potential to improve the quality of interactive storytelling in commercial video games by modelling the preferences of a single player through the automatic observation of her actions while she plays, and using the modelled preferences to dynamically choose the content of an interactive story. In this work, I present PaSSAGE (Player-Specific Stories via Automatically Generated Events), my implementation of an interactive storyteller that learns a player's preferences to create story experiences which improve over the traditionally authored stories in typical video games. I present the results of a user study involving 101 human participants, wherein, for certain subsets of players, PaSSAGE's player-specific stories are found to be more fun, to provide a heightened sense of player influence, and to be more appealing to replay than two traditionally authored stories.

# Acknowledgements


## Contributors

Although I organized and led the work on which this dissertation is based, my efforts were not made alone; since its inception, the PaSSAGE project has had several members, including two faculty members at the University of Alberta (Vadim Bulitko and Marcia Spetch), two undergraduate research assistants supported by awards from the National Sciences and Engineering Research Council of Canada (NSERC) (Eric Wasylishen and Trevor Bekolay), and one student hired through the High-school Internship Program run by the Department of Computing Science at the University of Alberta (Phillip Silver). All of these people are deserving of my many thanks, for the work presented in this dissertation could not have been achieved without their support.

## General Thanks

My family, for their unending and unmatched support of everything that I do.
Vadim, for allowing me the freedom to choose to do this work,
and putting in long hours to see it through.
Marcia, for her invaluable expertise, insightful comments,
and access to essential resources for our project's evaluation.
Eric, Trevor, and Phillip, for their time, effort, and insights,
and for putting up with me as their supervisor.
My research group, IRCL, for their helpful feedback and support of my work.
Duane Szafron, for promoting ScriptEase and drawing me to the U of A,
and for serving on my thesis defense committee.
Howard Hamilton, for introducing me to the world of academic research,
and convincing me to aim high.
Mike MacGregor, for chairing my thesis defense.
Ben Barnard and Stephen Hladky, for our lengthy discussions,
sanity checks, and friendship.
Julian and Rosie Macdonald, for doing the dishes, driving me around,
and getting my mind off school for a few hours every day.
Curtis Onuczko, Maria Cutumisu, and the rest of the ScriptEase team,
for putting up with my endless questions about scripting in Neverwinter Nights.
Michael Bowling, for giving me the opportunity to be a teaching assistant
in a class that I wish I could have taken myself.
Hector Padilla, for his knowledge of Neverwinter Nights, and for being a fantastic co-TA.
Jieshan Lu, Marcel Ball, and Cameron Makovichuk, for helping me run the user study.
All of the beta testers and study participants who helped me to evaluate my work.
NSERC and iCORE, for funding my research.
'Nuf Sed, the UADC, and the U of A Summer Band, for helping to keep me sane.

# Table of Contents


**1 Introduction** **1**
- 1.1 The Primary Goals of Storytelling . . . 1
- 1.2 Properties of Good Interactive Stories . . . 2
- 1.3 Story Events . . . 3
- 1.4 Story Decisions . . . 4
- 1.5 Storytelling: Traditional vs. Interactive . . . 5
- 1.6 Video Game Stories . . . 6
  - 1.6.1 Linear Stories . . . 6
  - 1.6.2 Branching Stories . . . 8
  - 1.6.3 Player-created Stories . . . 8
  - 1.6.4 Layered Stories . . . 8
- 1.7 Deferring Decisions . . . 9
- 1.8 Player Modelling . . . 9

**2 Problem Formulation** **11**
- 2.1 Interactivity in Storytelling . . . 11
  - 2.1.1 Defining Interactivity . . . 11
- 2.2 The Challenges of Player-informed Interactive Storytelling . . . 14
- 2.3 The Core Components of a Player-informed Interactive Storytelling AI . . . 14
  - 2.3.1 Knowledge Representation . . . 14
  - 2.3.2 Event Selection . . . 15
  - 2.3.3 Event Presentation . . . 16
  - 2.3.4 Input Handling / Feedback Acquisition . . . 16
  - 2.3.5 Player Modelling . . . 16
- 2.4 Domain Restrictions . . . 16
  - 2.4.1 Single Player . . . 17
  - 2.4.2 Commercial Video Games . . . 17
- 2.5 Performance Measures . . . 17

**3 Related Work** **19**
- 3.1 Interactive Storytelling . . . 19
  - 3.1.1 Story Decisions . . . 20
  - 3.1.2 Strategies for Interactive Storytelling . . . 22
  - 3.1.3 Simulation . . . 22
  - 3.1.4 Experience Management . . . 26

**4 Proposed Approach** **34**
- 4.1 Introduction to PaSSAGE . . . 34
  - 4.1.1 Primary Contribution to Interactive Storytelling . . . 35
  - 4.1.2 Styles of Play . . . 35
  - 4.1.3 Events as Encounters . . . 36
  - 4.1.4 The Hero's Journey . . . 36
  - 4.1.5 Design Ideals . . . 37
- 4.2 General Architecture . . . 38
- 4.3 General Implementation . . . 39
- 4.4 Knowledge Representation . . . 40
  - 4.4.1 Encounters . . . 41
  - 4.4.2 Storyworld State . . . 42
  - 4.4.3 Player Model . . . 42
- 4.5 Encounter Selection . . . 42

4.5.1 Encounter Selection . . . 43
4.5.2 Encounter Specification . . . 44
4.5.3 Encounter Refinement . . . 45
4.6 Encounter Presentation . . . 46
4.7 Input Handling / Feedback Acquisition . . . 47
4.8 Player Modelling . . . 47
4.8.1 The Player Model . . . 47
4.8.2 Leaning the Model: Action Annotations . . . 47
4.8.3 Using the Model: Branch Annotations and Clamping . . . 48

**5 Empirical Evaluation** **50**
5.1 The User Study . . . 50
5.1.1 Sources of Participants . . . 50
5.1.2 Experimental Setup . . . 52
5.1.3 Post-game Survey . . . 54
5.2 The Storyworld . . . 55
5.2.1 The Areas . . . 55
5.2.2 The Actors . . . 55
5.3 The Encounters . . . 57
5.3.1 Home . . . 58
5.3.2 The Call to Adventure . . . 58
5.3.3 Crossing the Threshold . . . 59
5.3.4 The Trials . . . 59
5.3.5 The Ordeal . . . 60
5.4 The Three Compared Versions . . . 60
5.5 Adaptive Gameplay Walkthrough . . . 61
5.6 Hypotheses . . . 62
5.7 Results . . . 63
5.7.1 Stage 1: University Students . . . 63
5.7.2 Stage 2: Female Gamers . . . 65
5.8 Analysis . . . 67
5.8.1 Additional Hypotheses: Comparing Subsets of Players . . . 67

**6 Discussion** **70**
6.1 Discussion of Results . . . 70
6.2 The User Study: Problems, Difficulties, and Lessons Learned . . . 71
6.2.1 Problems . . . 71
6.2.2 Difficulties . . . 72
6.2.3 Lessons Learned . . . 72
6.3 PaSSAGE: Limitations, Challenges, and Future Work . . . 72
6.3.1 Plot Consistency . . . 73
6.3.2 Story Planning with Player Prediction . . . 73
6.3.3 Author Uncertainty in Annotations . . . 73
6.3.4 Extended Evaluation . . . 73

**7 Conclusion** **75**

**Glossary** **76**

**Bibliography** **77**

**A User Study Materials** **80**

**B Detailed Evaluation Results: Stage 1** **100**

**C Detailed Evaluation Results: Stage 2** **110**

# List of Tables


3.1 Sample values for the five properties of each story decision. . . . . 20
3.2 Reorganized presentation of story decision properties with expanded explanations. 21
3.3 Story decision properties for Crawford's work. . . . . 24
3.4 Story decision properties for *FearNot!*. . . . . 25
3.5 Story decision properties for *Façade*. . . . . 29
3.6 Story decision properties for the Interactive Drama Architecture. . . . . 30

4.1 Summary of Laws' player types for pen-and-paper role-playing games. . . . . 35
4.2 Descriptions of the phases in Joseph Campbell's Hero's Journey. . . . . 36
4.3 Two branches of an encounter involving a murderer in hiding, with play-style annotations. Check marks indicate that the author expects that players of the given type will enjoy playing through the given branch (more check marks indicate greater expected enjoyment). Similarly, crosses indicate an expected aversion to playing through the given branch for players of the given type, and dashes indicate an expected indifference. . . . . 41
4.4 PaSSAGE's treatment of event properties as encounter properties toward making encounters generic and reusable. The rightmost column describes the extra author information that is required for PaSSAGE to decide a value for the corresponding encounter property. . . . . 42

5.1 Play-style annotations for each of the encounters that could chosen by PaSSAGE. Double lines separate phases of the Hero's Journey. . . . . 58
5.2 Confidence levels in support of my hypotheses for eighteen data subsets, for the first stage of the study. M = Male, F = Female, ETF = Easy To Follow, Low = Low Experience, and Exp = Experienced. These symbols describe restrictions on the qualities of the participants in each subset considered. Asterisks indicate unrestricted qualities. $N_A$ and $N_S$ represent the numbers of participants in the subset who played the Adaptive and Static stories, respectively. . . . . 64
5.3 Confidence levels in support of my hypotheses for eighteen data subsets, for the second stage of the study. M = Male, F = Female, ETF = Easy To Follow, Low = Low Experience, and Exp = Experienced. These symbols describe restrictions on the qualities of the participants in each subset considered. Asterisks indicate unrestricted qualities. $N_A$ and $N_S$ represent the numbers of participants in the subset who played the Adaptive and Static stories, respectively. . . . . 66
5.4 Means and standard deviations for player ratings of enjoyment (fun) for two subsets: those with low prior gaming experience (LE) who found the game easy to follow (ETF), and the disjunction between the previous two sets of players (players with high prior experience (HE - ratings $\geq 3$) or players who found the game hard to follow (HTF - ratings $\leq 3$)). . . . . 67
5.5 Average ratings for only the adaptive stories, comparing two subsets of players: those who found the game easy to follow and had low prior gaming experience (LE and ETF), and all other players (those who found the game hard to follow or had high prior gaming experience (HE or HTF)). Confidence values show support for the hypotheses that the players in the first subset (LE and ETF) rated the adaptive stories higher than did the players in the second subset (HE or HTF). . . . . 68
5.6 Average ratings for only the static stories, comparing two subsets of players: those who found the game easy to follow and had low prior gaming experience (LE, ETF), and all other players (those who found the game hard to follow or had high prior gaming experience (HE,HTF)). Confidence values show support for the hypotheses that the players in the first subset (LE,ETF) rated the static stories higher than did the players in the second subset (HE,HTF). . . . . 69

B.1 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. . . 101
B.2 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players who rated the game as being easy to follow. . . . . 101
B.3 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players. . . . . 102
B.4 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players. . . . . 102
B.5 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience. . . . . 103
B.6 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience. . . . . 103
B.7 Average ratings for Adaptive and Static stories, and percent confidence in t[illegible] Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience. . . . . 104
B.8 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience. . . . . 104
B.9 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with low prior video-gaming experience. . . . . 105
B.10 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with prior video-gaming experience. . . . . 105
B.11 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players who rated the game as being easy to follow. . . . . 106
B.12 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players who rated the game as being easy to follow. . . . . 106
B.13 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience who rated the game as being easy to follow. . . . . 107
B.14 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience who rated the game as being easy to follow. . . . . 107
B.15 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience who rated the game as being easy to follow. . . . . 108

B.16 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience who rated the game as being easy to follow. . . . . 108
B.17 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with low prior video-gaming experience who rated the game as being easy to follow. . . . . 109
B.18 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with prior video-gaming experience who rated the game as being easy to follow. . . . . 109

C.1 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. . . 111
C.2 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players who rated the game as being easy to follow. . . . . 111
C.3 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players. . . . . 112
C.4 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience. . . . . 112
C.5 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience. . . . . 113
C.6 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience. . . . . 113
C.7 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience. . . . . 114
C.8 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players who rated the game as being easy to follow. . . . . 114
C.9 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience who rated the game as being easy to follow. . . . . 115
C.10 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience who rated the game as being easy to follow. . . . . 115
C.11 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience who rated the game as being easy to follow. . . . . 116

C.12 Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience who rated the game as being easy to follow. . . . . 116

# List of Figures


1.1 Two layers of decisions to make for every story event. . . . . 5
1.2 At left: Alyx, one of the main characters in *Half-Life 2* [41]. At right: The player brandishes lightning in *BioShock* [21]. . . . . 7
1.3 Four common strategies for storytelling: Linear (a), Branching (b), Player-created (c), and Layered (d). Circles represent events, solid arrows indicate predefined connections to subsequent events, and dashed arrows indicate connections that may be created by the player. . . . . 7
1.4 At left: The player, Bastila, and Carth, locked in battle with a Sith Master in *Star Wars: Knights of the Old Republic* [24]. At right: A view of the player's city in *SimCity 4* [26]. . . . . 8
1.5 At left: The player challenges a warrior in *Oblivion* [23]. At right: The player fights for his character's life in *Fable*'s Arena [30]. . . . . 9

2.1 The five core components of a player-informed interactive storytelling AI. . . . . 15

3.1 Screen capture from *FearNot!* (c.f. [3]). . . . . 24
3.2 The Author-Director-Audience model for Interactive Storytelling. The author, director, and audience are all independent, the director makes relatively few story decisions, and there is no opportunity for the audience to influence their experience. 26
3.3 The Author-Director-Player model for Interactive Storytelling. The author supplies a small amount of knowledge to the director, the director makes relatively few story decisions, and the director conveys the story while receiving and reacting to player feedback (reactive interactivity). . . . . 27
3.4 The Author-Manager-Player model for Interactive Storytelling with reactive interactivity. Leveraging a large supply of author knowledge, the experience manager makes many story decisions and conveys them to the player, while receiving and reacting to player feedback. . . . . 27
3.5 The Author-Manager-Player model for Interactive Storytelling with deliberative interactivity. Leveraging a large supply of author knowledge and immediate player feedback, the experience manager makes many story decisions based on the feedback obtained from each player. . . . . 27
3.6 Screen capture from *Façade* (c.f. [20]). . . . . 28
3.7 Screen capture from *Haunt 2*, testbed for the Interactive Drama Architecture (c.f. [19]). . . . . 30
3.8 Screen capture from *Mirage* (c.f. [38]). . . . . 31

4.1 Joseph Campbell's Hero's Journey (based on similar figures found on the Internet [33]). Each phase represents a different type of event that often occurs in a heroic adventure. . . . . 37
4.2 PaSSAGE's general architecture. Bold text shows the player and the general system modules, regular text shows data communication, and italic text shows where each of the five challenges of Player-informed Interactive Storytelling are met. . . . . 39
4.3 The Aurora Neverwinter Toolset [7]. At left: the storyworld editor. At top-right: the actor conversation editor. At bottom-right: the program script editor. . . . . 40
4.4 Two example scripts showing how values in the player model are updated based on player actions, using an encounter involving an unknown, aggressive actor. The upper script would be attached to the "OnAttacked" event of the actor, while the lower script would be attached to the actor's "OnConversation" event. `pmChangeTypeValue` modifies the inclination toward the given type in the player model by the given value (*e.g.* the parameters `PM_STORY` and `PM_TYPE_HIGH` cause a substantial increase to the inclination toward the Storyteller type in the model. . . . . 43

4.5 Pseudocode for PaSSAGE's Encounter Selection algorithm. . . . . 44
4.6 An example of PaSSAGE attempting to run the "lost child" encounter described in Section 4.5.2. Circles represent actors (small nodes are children), the plus sign represents the player, and solid lines represent the walls of buildings. . . . . 46
4.7 Example calculation of encounter quality using branch annotations along with the values in the player model, without clamping the model values to be greater than or equal to zero. . . . . 48
4.8 Example calculation of encounter quality using branch annotations along with the values in the player model, with model values clamped to be greater than or equal to zero. . . . . 48

5.1 The poster that I created to attract participants for the second stage of the study. . . 51
5.2 The standard user interface to *Neverwinter Nights*. . . . . 52
5.3 My simplified user interface to *Neverwinter Nights*. . . . . 53
5.4 Metrics for player ratings in the user study survey. . . . . 54
5.5 The areas in my evaluation storyworld. Top row, from left to right: Downstairs in the player character's home; Upstairs in the player character's home; Eldon's Watch, the player's home village. Bottom row, from left to right: Maedorn Forest; Forest Clearing; Forest House. . . . . 56
5.6 The actors in my evaluation storyworld. Top row, from left to right: Annara Tel'mane, Father, Arnell Sampson. Bottom row, from left to right: The Troll, Jarnas Galennald, Vero Willian. . . . . 57
5.7 Differences in Troll dialogue used to hint both branches of the Distraction encounter. Left: Neutral Branch. Right: Fighter Branch. . . . . 59
5.8 The story space of my evaluation storyworld. Rounded nodes are in-game events, diamonds are endings labelled by acronyms: AER = Annara (the player's character) Eaten & Rescued, WE = Wizard Eaten, WER = Wizard Eaten & Rescued, WKT = Wizard Kills Troll, and WL = Wizard Leaves. Square nodes ($D_{\#}$) show decisions made by PaSSAGE (figure adapted from [50]). . . . . 61

# Chapter 1

# Introduction

Storytelling is arguably one of the earliest forms of human entertainment. From its beginning, storytelling was interactive; at any time, the listeners could interrupt the storyteller to make comments, ask questions, or otherwise influence what the storyteller was about to say next. With the advent of writing, however, this interactivity was lost; the author of a story was disconnected from his audience by the medium of the written word. Interactivity still persisted in storytelling through theatrical performances, but the limits of speech as a medium made quickly reaching large audiences while maintaining audience/actor interaction impossible, and the invention of television solved this problem by eliminating immediate, story-based interaction altogether. With modern computers, however, the opportunity for interaction in storytelling has returned, as techniques in Artificial Intelligence can serve as a proxy for the decision-making processes of story authors, and base a sequence of story events on interactions with an audience. For the purposes of this dissertation, I refer to this process of interactively creating and telling a story based on audience interaction as *player-informed interactive storytelling*.

This dissertation presents the efforts that I have undertaken to create a player-informed interactive storytelling system that uses techniques from Artificial Intelligence to dynamically choose the content of an interactive story, based on audience feedback gained through automatic observation. I named my work PaSSAGE, standing for "Player-Specific Stories via Automatically Generated Events", highlighting my aim for the stories that it generates to be *player-specific*.

## 1.1 The Primary Goals of Storytelling

For the purposes of this work, I consider the general goal of storytelling to be the delivery of a desirable experience to every member of a story's audience; ideally, this audience is large. What is a desirable experience? While some storytellers may wish to pass along a moral to their audience, I have chosen to direct this work toward providing audiences with experiences that are *entertaining*. Furthermore, although the term "entertainment" generally includes any sort of activity that is agreeably diverting, those that employ some form of audience/storyteller *interaction* are the focus of this

work. In particular, I aim to provide three desirable aspects of interactive entertainment through the telling of interactive stories: *Enjoyment*, *Agency*, and *Replay Value*.

### Goal 1: Maximize Enjoyment

Enjoyment is a measure of the pleasure that a viewer feels while experiencing a story's events; the mode of their experience might be reading a novel, watching a movie, or playing a video game.

### Goal 2: Maximize Agency

Agency is a measure of the viewer's feeling of having influence over their story experience. Although this measure is irrelevant for traditional books or movies, instilling this feeling during stories which allow some element of interactivity (*e.g.* verbal storytelling, improvisational acting, or video games) can be extremely valuable. In Psychology, agency refers to a person's capacity to influence the nature and quality of her life, and it is viewed as being a critical factor in determining personal well being [4, 46]. Given that experiencing a (fictional) story is an activity that one can engage in as a part of daily life, being able to influence the nature of this experience should be desirable as well. Recent work by Ryan has shown that for video games, a correlation between in-game agency and enjoyment does indeed exist [47].

### Goal 3: Maximize Replay Value

Replay value measures the viewer's willingness to experience a story (or perhaps variations thereof) multiple times. For books or movies, the urge to replay is often driven by fond recollections of the initial story experience, or a desire to re-examine the story's plot knowing in advance where it will lead. Stories that allow interaction, however, have the opportunity to encourage replay by renewing the *novelty* of the plot that they present through variations that depend on the interaction. Maximizing replay value is of particular importance to commercial video game developers, as supported by the fact that the most well-represented genre (25%) in the top one hundred best-seling video games of 2006 was the (highly replayable) Sports genre [8]. In this work, I hypothesize that experiencing a novel story with each subsequent play can increase the replay value of a given video game.

## 1.2 Properties of Good Interactive Stories

How might the primary goals of storytelling be achieved? More specifically, what properties must an interactive story have to satisfy these goals? In this section, I identify and motivate three key properties of good interactive stories, drawing from the theories of both narratology and ludology[1].

[1] Also known as "game studies", ludology is the study of video games.

**Story Property 1: Immersion**

Immersion is a measure of how engrossed an audience is in the events of their story experience. According to narratology, immersion (or involvement through empathy) occurs when the audience identifies strongly with the protagonist of the story [42]. In ludology, on the other hand, immersion is often characterized by *Flow* - the psychology of optimal experience [11]. To maintain Flow, the audience's experience must remain uninterrupted; potential interruptions include unbelievable occurrences, disruptions in presentation, or a cumbersome mode of audience interaction. Although both kinds of immersion are complimentary, in this work, I have aimed to achieve the latter, leaving the former as future work.

**Story Property 2: Global Structure**

Global structure describes the degree to which the events of a story are interrelated by causality; a story with strong global structure has highly interrelated events. Mateas states that "[*'good'*] *stories tend to have lots of global structure (...)*", and McKee relates that "[*causality*] *drives a story in which motivated actions cause effects that in turn become the causes of yet other effects, thereby interlinking the various levels of conflict in a chain reaction of episodes to the Story Climax, expressing the interconnectedness of reality*" [20, 42].

**Story Property 3: Plot Consistency**

Plot consistency is a measure of the plausibility of the relationships between the events that occur in a story. The more fantastic a relationship is, the more it must be supported by fantastic means, toward maintaining the audience's *suspension of disbelief* (*e.g. "In a flash, the troll had been transformed into a small white sheep. The wizard's magic was powerful indeed.*"). Concerning what he refers to as "Consistent Realities", McKee states that "[*each*] *fictional reality uniquely establishes how things happen within it. In* [*a story of Classical Design*[2]] *these rules cannot be broken - even if they are bizarre*" [42].

Toward obtaining these three properties of good interactive stories, the dependence of each property on the events of the audience's experience suggests that the selection of those events must be made with great care.

## 1.3 Story Events

The Oxford English Dictionary defines "story" as: "*a narrative of real or, more usually, fictitious events, designed for the entertainment of the hearer or reader*" [12]; fundamentally, stories are a sequence of events, each of which involves some form of action. In journalism, it is common to report the occurrence of an event by answering each of the following six questions: "*Who?*",

[2] "Classical Design means a story built around an active protagonist who struggles against primarily external forces of antagonism to pursue his or her desire, through continuous time, within a consistent and causally connected fictional reality, to a closed ending of absolute, irreversible change" (c.f. [42], pg. 45)

"*What?*", "*When?*", "*Where?*", "*Why?*", and "*How?*". Considering the types of facts that result from answering these questions, I propose that events can be well-described by six general properties:

- *Idea*: A brief description of the action that occurs.
- *Actors*: The people/creatures/forces that either perform part of the action or are acted upon.
- *Time*: The time at which the action begins.
- *Place*: The environment(s) in which the action occurs.
- *Actions*: The changes that actors make to themselves, other actors, or their environment.
- *Motives*: The notions held by actors that prompt their actions.

For example, consider this event: "*John rescues his friend Fred from the burning building by carrying him outside.*" In this case, the *Idea* might be "Rescue" or "Rescue from Fire". The *Actors* are John and Fred, the *Places* are the building and the area outside, and the *Action* is John carrying Fred outside. Although the *Time* of the event is not stated explicitly, given that the event's description is phrased in the present tense, one could assume that the *Time* is "now". One might also assume that John's *Motive* for saving Fred is based on a desire to prolong their friendship. It may seem strange to assign motives to actors that are neither people nor creatures; in such cases, I use the term "motive" to describe a possible reason why the action occurred. For example, one might say that the motive of (or reason for) an apple falling from a tree is the failure of its stem to resist the pull of gravity.

Throughout this work, I will refer to these six properties several times: they will be used to identify the set of decisions that must be made during the creation of a story, and will facilitate my discussion of relevant computer-based storytelling techniques.

## 1.4 Story Decisions

At its core, creating a story is about making decisions. Of all the possible sequences of events that an author might imagine, which ones should occur? When and where should they be set? Which characters should take part? What should the characters do, and how should their actions be motivated? For each of the six properties of an event, an author must make two decisions: i) "What should its value be?" and ii) "Why should it hold this value?" In later sections, it will be useful to think of these decisions in terms of how the questions they ask are answered: answering the former defines some property of an event, while answering the latter motivates that definition. It will also be useful to distinguish between the sources of the options that are available for each decision: defining events draws from the author's imagination and creativity, while motivating events draws from the author's style and knowledge of the craft of storytelling. To represent these differences, I group the decisions of each type into two layers, as shown in Figure 1.1.

| | Layer 1: Definition/Imagination | Layer 2: Motivation/Knowledge |
|---|---|---|
| *Idea* | **What** should happen? | **Why** should it happen? |
| *Actors* | **Who** should be involved? | **Why** should they be involved? |
| *Time* | **When** should it happen? | **Why** should it happen then? |
| *Place* | **Where** should it happen? | **Why** should it happen there? |
| *Actions* | **How** should it happen? | **Why** should it happen in that way? |
| *Motives* | **Why** should the actors act? | **Why** should that motivate them? |

Figure 1.1: Two layers of decisions to make for every story event.

**Layer 1: Definition/Imagination**

In making the decisions in Layer 1, an author completely defines a story event, deciding values for each of the six properties of story events. In the previous example about the burning building, the values described for each of the six properties were defined through an author's imagination.

**Layer 2: Motivation/Knowledge**

The results of the decisions in Layer 2 describe the author's intentions and motivations for his decisions in Layer 1. For example, one might ask: "*Why did John rescue Fred from the burning building?*" while the answer may be that the author wanted to demonstrate the strength of John's friendship with Fred.

## 1.5 Storytelling: Traditional vs. Interactive

The set of story decisions given in Section 1.4 applies to the creation of stories in general. However, a key point of distinction between different types of storytelling concerns the times at which these decisions are made: either before the telling of the story, or *while* the story is being told. Examples of the former include novels and films; every aspect of the audience's experience is decided before the first event is perceived. For the latter, examples include verbal storytelling, dramatic improvisation, and video games[3]; decisions leading to alternative sequences of subsequent events can be made while the story occurs, assuming the presence of an intelligent storyteller or actor (or a computer in his stead) that takes into consideration the reactions of his audience. I will refer to these two classes of storytelling as *Traditional Storytelling* and *Interactive Storytelling*, respectively.[4]

In Traditional Storytelling, achieving a desirable experience for every member of a large audience can be difficult; given the wide range of past experience and personal preferences between one audience member and the next, the creation of a story to entertain all of them becomes unfeasible and is often abandoned in favour of targeting a specific group of people (consider the Science Fic-

[3]While there are many video games that arguably have no story at all (computer *Solitaire*, for example), throughout this work I will use "video games", "computer games", and "commercial games" interchangeably to refer to games that do attempt to tell a story.

[4]Although one could envision a storytelling system (human or computer) that chooses subsequent events during the story without considering audience reaction, such as system could just as easily make its choices before the story was told, and would therefore fall into to the Traditional Storytelling class.

tion and Mystery genres of literature, for example). To reach a larger audience, elements of content can be included which appeal to various types of viewer, in the hopes of each viewer finding value in at least some of the story's elements. Unfortunately, doing so typically results in viewers also finding aspects of the story to be undesirable; the primary failing of Traditional Storytelling is that as audiences become larger, no single set of content will succeed in entertaining every member.

Interactive Storytelling, on the other hand, permits a more selective approach. Given the immediate availability of feedback from the audience *while* a story is being told, the content of the story can be *adapted* to suit the current audience. The challenge of delivering a desirable experience then becomes one of quickly gathering and interpreting the audience's feedback, and then using it to choose and convey the subsequent events of a story.

In verbal storytelling and dramatic improvisation, the creators of the story are on-hand during its presentation; meeting the given challenges thus depends on the skill of the storyteller or actors involved. In video games, however, the authors and designers of a game are separated from their audience by the process of publication and purchase, much like the book and movie industries. Lacking the ability to directly adjust their games for individual members of the audience, they instead rely on a computer to serve as their proxy. Typically, doing so involves creating a set of rules for the computer to follow which govern how the game's environment should react to various forms of player input (button presses, mouse movements, *etc.*). For example, a rule in an adventure-themed game might cause a hidden library door to open when the player interacts with a particular book on the shelf. If one considers the player's story to be the combination of the events that she perceives and the actions that she takes, then in this sense, her story is adapted based on her behaviour while she plays - some players may never interact with the book that triggers the hidden door to open, and thus would never experience that event. Such rules, however, often manage only the mechanics of a game's moment-to-moment operation; considerations of plot variation are either minimal or completely ignored. In other words, game rules always encode the knowledge of the game's designers, but rarely the knowledge of the game story's authors. In the following section, I discuss several current techniques for achieving variable plots in video game stories, and use them to motivate the focus of this work.

## 1.6 Video Game Stories

To date, the vast majority of storytelling strategies in video games have taken one of four familiar forms: linear, branching, player-created, or a layering of the previous three.

### 1.6.1 Linear Stories

Linear stories, often found in First-Person Shooter (FPS) games (*e.g. Half-Life 2*, *BioShock* [41, 21] - see Figure 1.2), limit players to experiencing a fixed sequence of story events. This limitation provides the authors of such stories with a great deal of expressive freedom, as they can be certain

Figure 1.2: At left: Alyx, one of the main characters in *Half-Life 2* [41]. At right: The player brandishes lightning in *BioShock* [21].

that the player's in-game choices (such as which enemy to shoot first or which side of a hallway to run along) will have no relevant impact on the story that they wish to tell. The structure of a linear story is shown in Figure 1.3 a).

As one might expect, the replay value of such games suffers as a result of there being no story-relevant alternatives to explore; choosing to fight the game's AI-controlled enemies in a different way will yield a different player experience, but the novelty of the story's plot is lost after the first play. Furthermore, lacking alternatives in the story requires every player to experience the same sequence of events, regardless of any preferences that they may have. To appeal to a wider audience of players, the typical approach is to include elements of game-play from outside the genre (*e.g.* the driving sequences in *Half-Life 2*). Given the wide range of preferences held by the potential players of a given game, the likely result is that some players will enjoy particular events while other players do not, making the one-size-fits-all strategy of linear stories a problematic approach.

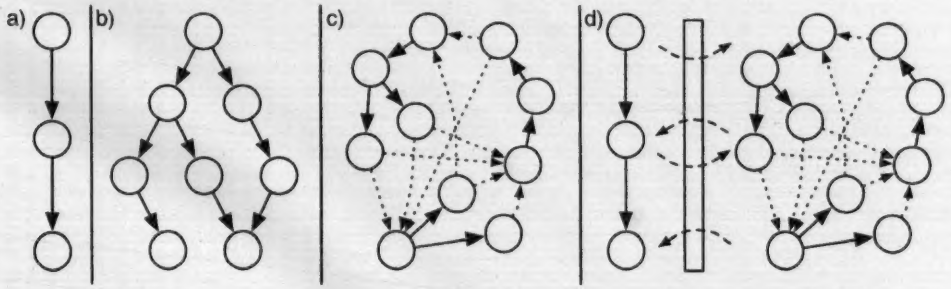


Figure 1.3: Four common strategies for storytelling: Linear (a), Branching (b), Player-created (c), and Layered (d). Circles represent events, solid arrows indicate predefined connections to subsequent events, and dashed arrows indicate connections that may be created by the player.

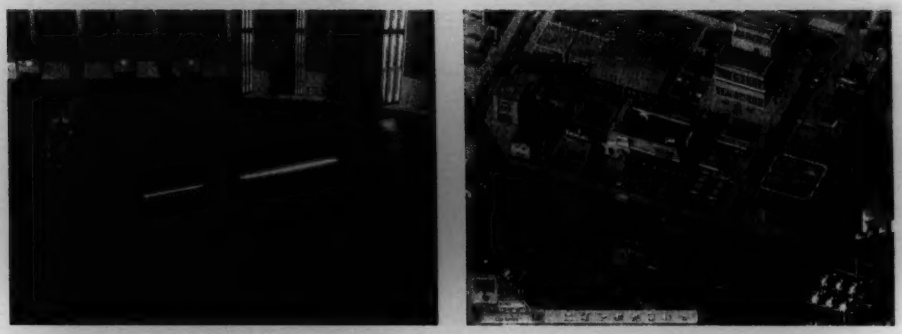

Figure 1.4: At left: The player, Bastila, and Carth, locked in battle with a Sith Master in *Star Wars: Knights of the Old Republic* [24]. At right: A view of the player's city in *SimCity 4* [26].

### 1.6.2 Branching Stories

Branching stories, found most often in Adventure or Role-Playing games (*e.g. Star Wars: Knights of the Old Republic* [24] - see Figure 1.4) improve over linear stories by offering a set of story-relevant decisions for the player to make. With each decision, the player can experience an alternative sequence of events, as shown in Figure 1.3 b). Like linear stories, branching stories provide a highly expressive medium for game story authors, as each alternative event is created similarly to those in a linear story. Unfortunately, the amount of work involved in creating each alternative event often outweighs the benefits gained in terms of additional player decisions, as the ratio of new alternative events to new player decisions is often much higher than one, making the creation of a large number of decision opportunities prohibitively expensive. Furthermore, branching stories often include some form of 'foldback' scheme, which joins together sequences of alternative events into a single subsequent event, reducing the player's sense of agency in the story.

### 1.6.3 Player-created Stories

In Simulation games (*e.g. SimCity 4* [26] - see Figure 1.4), the events forming the stories that players experience are based almost entirely on the actions that they take. Short sequences (or branches) of events are connected using predefined game rules (the solid arrows in Figure 1.3 c), and temporally linked together by the player's choice of actions (the dashed arrows in Figure 1.3 c). Although the strong focus of player-created stories on moment-to-moment player actions offers a high degree of agency, the stories that result rarely have global structure (Story Property 2), because the game rules that manage the player's experience consider only brief sequences of events.

### 1.6.4 Layered Stories

Layered stories, which combine a linear or branching story with a simulation-based world, have become increasingly common in role-playing games (*e.g. Oblivion, Fable* [23, 30] - see Figure 1.5).

Figure 1.5: At left: The player challenges a warrior in *Oblivion* [23]. At right: The player fights for his character's life in *Fable*'s Arena [30].

As players experience the so-called "main" linear or branching story, the opportunity is almost always available for them to effectively pause that story in favour of exploring the simulated world in which it is set. This layered approach is useful in that it provides players with diversions from the main story being told; if players are disappointed with the current part of the story, they have the freedom to go and experience other sequences of events in the storyworld, called *side-quests* (this freedom is represented by the dashed arrows linking the linear and player-created stories in Figure 1.3 d). Unfortunately, side-quests typically serve little purpose in terms of the main story other than making the player's character strong, smart, and skilled enough to survive to see its end.

## 1.7 Deferring Decisions

To alleviate the problems described above for both Traditional Storytelling and the usual video game strategies, I propose that the decisions that are typically made by an author at the time of their story's creation must be *deferred* to the time of the story's telling in a way that *dynamically incorporates feedback* from the audience. Specifically, *all* of the story decisions presented in Figure 1.1 should be made based on audience interaction in an attempt to satisfy the goals of maximizing enjoyment, agency, and replay value, in the context of producing stories that are immersive, consistent, and have strong global structure. Given an audience that interacts with a storyteller to obtain some form of entertainment, one might describe their experience as *play*. As such, I will henceforth use the term *players* to refer to members of an audience who, in addition to viewing the events of a story, have the opportunity to interact with the storyteller as well.

## 1.8 Player Modelling

As I stated above, the interactive nature of Interactive Storytelling presents a way to avoid the one-size-fits-all approach of Traditional Storytelling. As a storytelling medium, Interactive Storytelling is uniquely well-poised to create stories whose content is *tailored* for each individual player by

gathering and leveraging the feedback that they generate while they play. In general, using gathered information about a player is known as *player modelling*; by automatically observing the actions that a player takes in response to the events that she experiences, a model of her preferences, personality, interests, or skills can be inferred. There are many ways to construct such a model, some of which will be discussed in later chapters. For the moment, consider the following potential interaction as an example of how a storyteller might model a particular player:

> *Storyteller*: "Prince Vi'dal was a man of great skill and ambition, his sharpness of wit rivalled only by the speed of his blade. None in the realm would dare to challenge him, for public humiliation tempted no one.
> A quiet time came over the kingdom, and Prince Vi'dal grew more and more restless. Having no one to challenge him, he could feel his skills slipping away."
> *Player*: "It sounds like the prince needed to find himself a princess..."
> *Storyteller*: "Ha ha! That may have helped indeed!"

In this exchange, the storyteller describes the fictional prince as a cunning swordsman, appealing to potential player interests including royalty, bravery, and challenges of skill. The player, however, responds with an interest in courtship and romance; the storyteller takes note of this information and responds to the player's comment. Given this new knowledge, the storyteller is now better equipped to choose the content of the remainder of the story. Although it may not always be what the storyteller expects, player information can be gained from even a single phrase of text.

## Summary

In this chapter, I introduced Storytelling as the art of both crafting and conveying an entertaining sequence of events to a large audience of viewers. I identified three desirable aspects of entertainment as goals to strive for in storytelling, namely the maximization of each viewer's sense of *enjoyment*, her sense of *agency*, and her perception of the *replay value* of the story that she experiences. I noted that to achieve the second and third of these goals, some form of dynamic interaction between the viewer and the storyteller is required, and introduced this process as *Interactive Storytelling*. I compared Interactive Storytelling to (non-interactive) *Traditional Storytelling* and highlighted the advantages and shortcomings of several related strategies that are currently employed in the commercial video game industry. I identified a core set of properties for describing an event in a story, and from them constructed a set of decisions that must be answered during the creation of such an event. Finally, I proposed that to overcome the shortcomings seen in current video game stories, each of these decisions must be *deferred* to the time of the story's telling, and be *based on knowledge of the viewer* that is obtained through *player modelling*.

# Chapter 2

# Problem Formulation

In this work, I aim to achieve the primary goals of storytelling (as presented in Section 1.1) through computational means; namely, the application of Artificial Intelligence (AI) techniques in the setting of Interactive Storytelling. In this chapter, I describe and motivate my view of Interactivity in a Storytelling setting, leading to the notion of *Player-informed* Interactive Storytelling. I outline a set of challenges that a player-informed, interactive storytelling AI must overcome toward producing and telling stories that have the three desirable properties of immersion, global structure, and plot consistency, while maximizing the enjoyment, agency, and replay value found by its audience. I then describe a minimal set of components that are necessary for the creation of a player-informed interactive storytelling AI that meets the given challenges, outline the restrictions that I applied to focus the domain of this work, and conclude by stating the performance measures that I will use to evaluate this work.

## 2.1 Interactivity in Storytelling

In 1991, Laurel presented a set of thirteen functions that an interactive "Playwright" must perform [17]; in 2005, Crawford reduced this list to three (*listen*, *think*, and *speak*) [10]. Although Crawford's list is near to being an appropriate metaphor for what I aimed to achieve with this work, as I explain below, it lacks one crucial element of the processes that I consider to be necessary for Interactivity in Storytelling. For the following discussion, I reformulate Crawford's list in more general terms, namely, (*attend*, *deliberate*, *act*)[1].

### 2.1.1 Defining Interactivity

Although a general discussion of interactivity is beyond the scope of this work, I use the following sections to suggest what having the property of interactivity implies for a computational system.

The Oxford English Dictionary defines the adjective "interactive" as "*1. reciprocally active;*

[1] Given that the Oxford English Dictionary defines the verb "listen" as "*to hear attentively; to give ear to; to pay attention to (a person speaking or what is said)*" [12] and Crawford's assertion that his list should be interpreted as a metaphor [10], I propose that this reformulation of Crawford's list preserves his original meaning.

*acting upon or influencing each other*", and "2. *pertaining to or being a computer or other electronic device that allows a two-way flow of information between it and a user, responding immediately to the latter's input.*". Also, it defines the verb "act" as "*to put in motion, move to action, impel; to actuate, influence, animate*" [12]. From these definitions, it follows that any computational, interactive system must have the following three properties: 1) it must be influenced by its user, and 2) influence its user by 3) responding immediately to her input. The first two properties are covered by Crawford's (reformulated) list: by *attending* to the user's input, the system is influenced, and by *acting* on the user, the system influences its user (assuming that the user is aware of the system's actions). The third property, however, is addressed by neither *speaking* nor *acting*, as either of these can be performed without responding to the user's input (*e.g.* in a conversation between two people, one might choose to change the subject, ignoring what the other had just said). In light of this shortcoming, I propose to revise the general version Crawford's list of interactive storytelling functions by replacing *act* with *react*, as the Oxford English Dictionary defines "react", as "*to act in return, or in turn, upon some agent or influence*" [12]. The new list of interactive storytelling functions now becomes (*attend*, *deliberate*, *react*).

Consider, now, a relaxed version of this new list, where *attention* is replaced by *reception* (or *listening* by *hearing*), and *deliberation* is removed: (*receive*, *react*). Perhaps surprisingly, the three properties of an interactive system are still satisfied: *Reaction* covers the second and third properties as before, and the Oxford English Dictionary defines the verb "receive" as "[...] *to take delivery of (a thing) from another, either for oneself or for a third party.*" [12], implying that the receiver is influenced by virtue of its altered state.

**Attention vs. Reception**

The argument above suggests that two functions, *receive* and *react*, are together sufficient for creating an interactive system. However, if this is so, then why did Crawford suggest that *listening* (*attention*) is necessary instead of *reception*, and that *deliberation* is necessary as well? Toward answering this question, consider the Oxford English Dictionary's definition of the verb "attend": "*to turn the mind to, give consideration or pay heed to, regard, consider*". It follows from this definition that *attention* requires *deliberation*, but is it necessary for an interactive storyteller to *attend* the actions of its players instead of simply *receiving* them? I propose that the two answers to this question define two different types of interactivity: *reactive*, and *deliberative*.

**Reactive Interactivity**

For reactive interactivity, *reception* is sufficient. For every user action, only one potential system reaction exists, and receiving a user action triggers the system's corresponding reaction. There is no need for the system to consider any potential alternatives, for none exist. The majority of commercial video games employ reactive interactivity, both for the management of the game's environment (*e.g.*

game rule enforcement, or physics simulation), and the direction of the game's story (*e.g.* the linear, branching, player-created, and layered storytelling strategies in Section 1.6). Furthermore, given that no potential alternative reactions must be considered for reactive interactivity, the system need not necessarily *deliberate*, although it may still do so; that is, in addition to reacting to the user's actions, the system may independently decide to act based on other sources of information, such as a knowledge base of dramatic theory or the actions of autonomous game characters.

**Deliberative Interactivity**

For deliberative interactivity, *attention* is necessary; instead of the user's actions directly determining the system's reaction, they serve to inform the system's consideration of multiple potential alternative reactions. By the definition given above for the verb "attend", *deliberation* is also a necessary component of deliberative interactivity. However, this deliberation is not limited to considerations based solely on the user's actions; indeed, one of the primary differentiators in Interactive Storytelling research is the basis of the storyteller's deliberations. That being said, many recent research efforts in Interactive Storytelling are attempting to create interactive storytelling AIs that employ deliberative interactivity, including the effort that is the focus of this work.

**Learning for Deliberative Interactivity**

As defined, deliberative interactivity requires a system to 1) decide between several potential reactions, and 2) base these decisions on actions taken by the user. In terms of storytelling, while it may be true that a storyteller could employ deliberative interactivity by considering only the most recent player action, I propose instead that it is necessary for deliberative interactivity to *maintain* some knowledge of its player's actions from one interaction to the next. Although a formal proof of this assertion remains as future work, an intuitive argument is as follows. Supposing that it is reasonable to expect that a player's actions will not always be indicative of her personality, preferences, or intent (*e.g.* due to erroneous input), it seems dangerous to base the events of a story on only the most recent player action. As an alternative, a history of the player's actions could be kept and used to calculate what would likely be a better general estimate of the player's behaviour or traits. By keeping such a history, the storyteller would learn about the player.

**Deliberative Storytelling vs. Deliberative Interactivity**

When considering the above definitions, it is critical to realize that although an interactive storyteller may deliberate upon what action it should take (*i.e.*, it may *deliberate*), it is the *basis* of its deliberations that defines the type of interactivity that it has with the player: if the storyteller's deliberations are based on the player's actions, then the interaction is deliberative; otherwise, it is reactive. Furthermore, these two types of interactivity are not exclusive; while a deliberative storyteller might give consideration to most of the player's actions (deliberative interactivity), any player actions that were not required for this process could be handled reactively instead.

## 2.2 The Challenges of Player-informed Interactive Storytelling

For the remainder of this work, I will focus my discussion on interactive storytelling AIs that aim to employ some form of deliberative interactivity. In a forthcoming publication, I refer to such systems as being *player-informed* [51]. To create a player-informed interactive storytelling AI that achieves the primary goals of storytelling while producing good interactive stories (Sections 1.1 and 1.2), the following five challenges must be met.

**Storytelling Challenge 1:** *Gather* feedback from the player of a story;

**Storytelling Challenge 2:** *Interpret* the gathered feedback to learn about the player;

**Storytelling Challenge 3:** *Relate* this interpretation to potential subsequent story events;

**Storytelling Challenge 4:** *Decide* which subsequent events should occur, incorporating player feedback while ensuring a consistent, structured, and immersive plot;

**Storytelling Challenge 5:** *Convey* the chosen events to the player of the story.

Storytelling Challenges 1, 2, and 3 all concern *attending* to the player's actions, while Storytelling Challenges 4 and 5 concern *deliberating* about subsequent events and *reacting* to present them to the player, respectively. Without meeting Storytelling Challenge 1, no feedback would be available on which to base the storyteller's interactions. Without meeting Storytelling Challenge 2, the storyteller's reactions would be based solely on the most recent player action, and I argued against this approach in Section 2.1.1. Without meeting Story Challenge 3, the storyteller would have no relationship between the learned player information and potential subsequent story events, leaving it unable to base its decisions on gathered player feedback (as required by deliberative interactivity). Without meeting Storytelling Challenge 4, no story events would be selected to occur, and without meeting Storytelling Challenge 5, the player would never experience the story's events.

## 2.3 The Core Components of a Player-informed Interactive Storytelling AI

To create a player-informed interactive storytelling AI that meets the challenges given above, several key components are required. In this section, I propose that the core components of such an AI must minimally contain five phases of a continuing cycle: knowledge representation, event selection, event presentation, player input handling with feedback acquisition, and player modelling (Figure 2.1). Lacking any of these components, the challenges of Player-informed Interactive Storytelling cannot not be met.

### 2.3.1 Knowledge Representation

As I discussed in Section 1.4, creating a story is about making decisions. To make these decisions automatically, an author's knowledge must be encoded in a computer-readable form, and doing

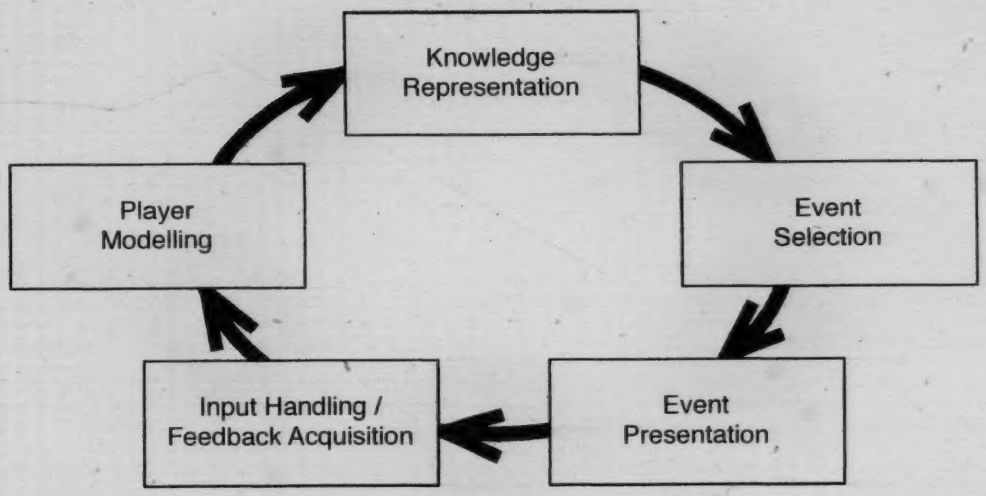


Figure 2.1: The five core components of a player-informed interactive storytelling AI.

so requires some form of *knowledge representation*: a collection of facts and relationships which describe, at the very least:

1.) the story's setting (the initial/current state of the story's world),

2.) every potential story event (the ways in which the world can change),

3.) a cast of characters (the agents that affect each change), and

4.) a set of relationships between expected feedback and potential subsequent events.

Knowledge representation helps to meet Storytelling Challenge 3.

### 2.3.2 Event Selection

Event selection is the primary decision-making process of every interactive storytelling AI; it is responsible for determining what should happen next in the course of a story. This determination is made by considering the questions posed in the two layers of story decisions in Figure 1.1, and answering those which were not answered directly by the author. The set of questions that the AI must answer helps to determine what additional knowledge must be specified in the Knowledge Representation phase. For example, if an author chooses to defer the selection of an event's actors to run-time, the AI must have access to the author's knowledge of what makes an actor suitable to play each part in that event. As will be discussed later on, some interactive storytelling AIs select events directly from a set of potential events to manage the player's experience, while others simulate the basic behaviour of the story's actors, letting interesting events arise from the complexity of their interactions. Event Selection helps to meet Storytelling Challenge 4.

### 2.3.3 Event Presentation

Once an event has been selected to occur, it must be conveyed to the player. Doing so may be accomplished in a variety of ways, including displaying segments of text, playing clips of audio, or displaying images and videos. With current video game technology, many of these media can now be generated automatically, with the most ambitious games presenting the player with an immersive, interactive, virtual 3-dimensional environment that they may explore as the setting of an interactive story. Event Presentation helps to meet Storytelling Challenge 5.

### 2.3.4 Input Handling / Feedback Acquisition

To enable interactivity and the acquisition of player feedback, some form of player input must be allowed during the course of the story. Examples of possible modes of player input include key/button presses on a keyboard or game controller, mouse clicks which select actions to perform from options appearing on-screen, natural language text typed freely by the player, or external sensors which monitor the player's physiology, movements, or facial features. For example, the game controller for Nintendo's Wii entertainment system combines button presses with motion tracking technology to serve as both a pointing device for selecting on-screen options, and a direct input of player arm motions for video games such as tennis, golf, and race car driving [34]. Input Handling and Feedback Acquisition help to meet Storytelling Challenge 1.

### 2.3.5 Player Modelling

Once player feedback has been acquired, a player-informed interactive storytelling AI must be able to calculate what it means, as this knowledge can then be used to guide the selection of subsequent story events. Player modelling is the practice of interpreting a player's feedback as indications of her personality, preferences, interests, or skills. In recent First-Person Shooter video games, statistics concerning the player's skill at playing are gathered automatically (feedback acquisition), and then interpreted online as measures of how difficult that player is finding the game to be [37]. These measures are then used to influence the difficulty of future opponents, in an attempt to provide the player with an enjoyable level of challenge. Auto-dynamic difficulty adjustment is a particular branch of Player Modelling that has received much recent attention [2, 49]. Player Modelling helps to meet Storytelling Challenge 2.

## 2.4 Domain Restrictions

In designing an interactive storytelling AI to meet the challenges given above, I have chosen to make certain restrictions to focus the domain of the problem. For the remainder of this work, unless otherwise stated, the following restrictions will be assumed.

### 2.4.1 Single Player

Instead of attempting to deliver one story to a large number of viewers simultaneously and have them all be entertained, I aim to to create an AI that builds and tells a new interactive story for each individual player, independently of all others. Allowing only one player per story simplifies the problem by limiting the audience feedback (which must be processed by the AI) to one source: the current player. While multiple sources of feedback would almost certainly cause conflicts in reacting to varying types of players, focusing on a single player should more easily allow a model of her interests, personality, or preferences to be effectively used to select subsequent story events. Given the prevalence of story-based video games as single player adventures, this simplification should have a minimal effect on the usefulness of this work.

### 2.4.2 Commercial Video Games

To ensure that this work maintained a focus on practical applicability, I chose to design my story-telling AI in the context of a commercial video game. In this context, the three primary goals of maximizing fun, agency, and replay value are well understood and often achieved through gameplay mechanics by the designers of a game. The techniques used by game authors to achieve these goals through interactive stories, however, have changed little in the past 30 years, remaining plagued by the problems that I discussed in Section 1.6. By focusing this work on improving interactive story-telling in commercial video games, I hope to address their current storytelling limitations in a novel and useful way.

## 2.5 Performance Measures

To judge the success or failure of the player-informed interactive storytelling AI that I describe as the focus of this work, I will compare the adaptive stories that it produces to two static (non-adaptive) stories of similar scope, based on player ratings obtained via post-game surveys in a human user study. In particular, I will consider the averages of the ratings obtained for metrics corresponding to each of the three primary goals of storytelling (Enjoyment, Agency, and Replay Value), performing significance tests against the null hypotheses ($Metric_{Adaptive} \leq Metric_{Static}$), where each such hypothesis is constructed by replacing $Metric_{Adaptive}$ and $Metric_{Static}$ with the average ratings obtained for the adaptive and fixed stories, respectively, for that particular metric on the survey (*e.g.* $Agency_{Adaptive} \leq Agency_{Static}$). For each null hypothesis, I will state the level of confidence that I found in support of rejecting it in favour of my alternative hypothesis, ($Metric_{Adaptive} > Metric_{Static}$), which states that the stories produced by my player-informed interactive storytelling AI will, on average, be rated more highly than the fixed stories that I compare it against.

## Summary

In this chapter, I identified the problem that I aim to solve in this work as the creation of an interactive storytelling AI that achieves the three primary goals of storytelling. I introduced and motivated the concepts of *reactive* and *deliberative* interactivity, referring to systems that employ the latter as being *player-informed*. I presented the challenges that a player-informed interactive storytelling AI must overcome, and suggested a minimal set of core components for any player-informed interactive storytelling AI. I stated two restrictions that I have adopted to focus my work: the simplification of allowing only one player to experience each story, and the concentration on commercial video games in the hopes of improving the quality of the stories therein. I concluded by providing the performance measures that I will use to assess this work based on the results of a human user study.

# Chapter 3

# Related Work

In this chapter, I discuss a host of techniques that aim to craft and tell interactive stories via computational means. Given that the field is relatively young, many names for it have arisen: "*Interactive Storytelling*", "*Interactive Story*", "*Interactive Narrative*", "*Interactive Drama*", and "*Virtual Storytelling*" are but a few. It is necessary to clarify, however, that although I have adopted the phrase "Interactive Storytelling" for this work, none of the given phrases adequately capture what I aim to achieve: the interactive telling of interactive stories. "Interactive Storytelling", for example, requires that the *telling* of a story be interactive; that is, the storyteller must dynamically react to feedback from its audience. "Interactive Story", on the other hand, implies that the events of a story will change based on the actions of its player. Although a grandfather can tell a story to his grandchild interactively (*i.e.*, the child may interrupt and ask questions, prompting the grandfather to elaborate), it is unlikely that the story that results is interactive; a pre-determined story is told interactively to the child. However, many video game stories are interactive (through the branching, player-created, or layered strategies in Section 1.6), yet they still fail to achieve the three primary goals of storytelling. As I discussed earlier, this failure is due to the fact that almost all plot-related decisions are made long before the story is told, remaining largely independent of the particular feedback that is offered by each individual player. Although the stories in many video games are interactive, the telling of these stories remains non-interactive and fixed; that is, the story interactivity is *reactive* instead of *deliberative* (Section 2.1.1). Given my choice to focus this work in the setting of commercial video games, the emphasis of "Interactive Storytelling" on interactively *telling* the games' interactive stories led me to choose that phrase over the others to describe this work.

## 3.1 Interactive Storytelling

In this section, I describe several past and current storytelling systems which aim(ed) to achieve the interactive telling of interactive stories. Although many such systems exist, I will focus my discussion on the eight which are most directly related to the research that I present in this work.

### 3.1.1 Story Decisions

To facilitate my discussion of related Interactive Storytelling techniques, I now refer back to the story decisions that I presented in Chapter 1 (Figure 1.1). When considering any Interactive Storytelling system, it is important to understand five things about each of the story decisions in Layer 1:

1.) **What** decision was made?
2.) **Who** made the decision?
3.) **When** was the decision made?
4.) **How** was the decision made?
5.) **Why** was the decision made in that way?

Similarly to how answering the six story decisions in Layer 1 yields the properties of an event, the answers to these five decision questions yield the properties of each story decision:

- *Decision*: The chosen properties of the event being described.
- *Decider*: The party who made the decision - either the player or the author.
- *Time*: The time at which the decision was made - either offline (before the story) or online (during the story).
- *Method*: The mechanism used to make the decision - this may be author imagination, a particular (computer) algorithm, or an in-game player action.
- *Justification*: The author's, system designer's, or player's reason for using the decision-making method that they chose.

Considering each of these properties with respect to each of the six story decisions in Layer 1 gives rise to Table 3.1. The table has been filled in with sample values to aid in explaining how it should be read.

| | **Decision** | **Decider** | **Time** | **Method** | **Justification** |
|---|---|---|---|---|---|
| *Idea* | Rescue | Author | Offline | Imagination | Unrestricted |
| *Actors* | John & Fred | Author | Online | Friend Finder | Plot Consistency |
| *Time* | Act 3 | Player | Online | Warned John | Event Trigger |
| *Place* | Burning Building | Author | Offline | Imagination | Unrestricted |
| *Actions* | J Carry F Outside | Author | Online | AI Planner | Goal Satisfaction |
| *Motives* | Preserve Friendship | Author | Offline | Imagination | Unrestricted |

Table 3.1: Sample values for the five properties of each story decision.

Consider the first row of answers in Table 3.1 (*Idea*). Reading from left to right, we learn that the event in question concerns some kind of rescue, and that this decision was made offline by the author,

drawing freely from his imagination. The second row (*Actors*) shows that John and Fred are the actors in this event, and that this author decision was deferred to run-time (*i.e.*, made online) using an algorithm to automatically select two actors based on the consistency requirements of the actors being in the same area as the event and friends with one another. The third row (*Time*) shows that the rescue event occurred in Act 3 of the story, and that it happened at this time because the player found John and warned him of Fred's peril. The fourth row (*Place*) shows that the rescue event happened inside a burning building, and that the author chose this location from his imagination offline. The fifth row (*Actions*) shows that the rescue event consisted of John carrying Fred out of the burning building, and that the decision for this action to occur was made online by an algorithm designed to automatically plan John's actions toward achieving a given goal. Finally the sixth row (*Motives*) shows that John's motive for rescuing Fred was the preservation of their friendship, and that this motive was chosen offline by the author by drawing from his imagination.

For the following sections, it will be useful to omit the second column ("Decision") of Table 3.1 from subsequent tables; doing so will also allow longer explanations for the column that describes the method used to make each decision ("Method"). Table 3.2 shows how the columns will be organized henceforth, and gives examples of the expanded explanations for the "Method" column.

| | **Decider** | **Time** | **Method** | **Justification** |
|---|---|---|---|---|
| *Idea* | Author | Offline | Imagination | No Restrictions |
| *Actors* | Author | Online | Friend Finder - An algorithm automatically finds two actors that satisfy the following conditions:<br>- one actor is in the building and the other actor is not<br>- the actors are friends | Plot Consistency |
| *Time* | Player | Online | Warned John - After escaping from the burning building herself, the player typed "Fred's still inside" while standing near John. | Event Trigger |
| *Place* | Author | Offline | Imagination | No Restrictions |
| *Actions* | Author | Online | AI Planner - As soon as the event is triggered, John automatically gains the goal to preserve his friendship with Fred, and evaluates his available actions to determine which ones will most likely achieve his goal. | Goal Satisfaction |
| *Motives* | Author | Offline | Imagination | No Restrictions |

Table 3.2: Reorganized presentation of story decision properties with expanded explanations.

By filling out this table for several of the storytelling systems that I discuss in detail with respect to an example event made common to all of the systems (the rescue event of Table 3.1), I aim to concisely summarize the operation of each system and highlight the inter-system differences and similarities that exist. Among the systems that I discuss in the following sections, there are several for which the rescue event could not have occurred exactly as I described it above (*e.g.* the "carry" action may not be defined). In such cases, I will nevertheless describe how this event might occur within the design of the system being considered.

### 3.1.2 Strategies for Interactive Storytelling

In general, the two primary strategies for achieving interactive storytelling via computational means are *simulation* and *experience management*. In the following sections, I discuss several examples of each kind of strategy, focusing in particular on how they implement the core technologies of player-informed interactive storytelling AIs that I identified in Section 2.3. Given that the player-informed interactive storytelling AI that I present in this work follows a hybrid approach and focuses on explicitly modelling the player to obtain useful feedback, I reserve detailed discussions for systems whose techniques or motivations are very similar to my own system's design.

### 3.1.3 Simulation

Simulation treats the world of a story as a highly collaborative system, wherein each (non-player) character is a perceptive, embodied, autonomous agent; that is, each character can perceive its environment, is situated in the environment (*i.e.*, it "exists" at some position), and is independently able to select and take actions that affect its environment (and other characters) in some way. Often, such agents are also goal-directed, employing some deliberative planning mechanism to select a sequence of actions that leads to a particular (desired) world state. By placing several of these agents in an environment, giving them actions that allow them to interact with one another, and providing each agent with a set of goals to achieve, a sequence of events will occur that an observer might perceive to be a story. By additionally allowing a player to intervene with these characters (either by controlling one of them directly or by manipulating their environment), an interactive story can be interactively told by the characters of the story themselves.

#### The Sims

A simple version of a simulation-driven story is Electronic Arts' *The Sims* [27]. In *The Sims*, the player interacts with the game world by managing the lives of one or more characters who live in a (virtual) house. There are many different characters in the world, and given that the player can only influence the actions of one of them at a time, the others are driven by AI behaviours that simulate the activity of daily life (*e.g.* watching television, doing dishes, or socializing with other "Sims"). Sims choose what to do based on satisfying a basic set of needs, including getting sleep, relieving their bladder, and having fun. Objects in the Sims' homes advertise their ability to satisfy various needs (*e.g.* using a bed satisfies a need for sleep); this informs the Sims as to where in the home they should go to satisfy their currently pressing needs. Although it has been argued that *The Sims* is not an example of Interactive Storytelling (due to its focus on simulating the more mundane aspects of life rather than interesting dramatic events) [10], I describe it here because it offers excellent example of a simulated world driven by perceptive, embodied, autonomous agents.

**The Erasmatron and Storytron**

In his recent book, *"Chris Crawford on Interactive Storytelling"*, Chris Crawford presents a set of lessons learned over thirteen years spent investigating and implementing interactive storytelling technology [10]. From Crawford's perspective, good stories are about people, not things; this highlights his motivation for using a simulation-based approach for his work. For example, for two characters, Fred and Jane, if Fred is caught stealing a book from Jane, what matters most are Fred's motivations for stealing it and Jane's subsequent feelings toward Fred; details concerning the identity of the book, the time of day of the theft, and Fred and Jane's current locations are all secondary. Based on this idea, Crawford's two interactive storytelling engines, The Erasmatron and Storytron, focus intently on simulating dramatic encounters between the actors of a story.

In Crawford's terms (which are adapted from general narratology), dramatic encounters occur when actors in a scene carry out a set of *verbs* - actions involving two or more participating actors. In the previous example, the verb might be *Steal*, where Fred is the *Subject*, Jane is the *Direct Object*, and the book to be stolen is a *Secondary Object*; both the Subject and the Direct Object must be actors. In addition to having at least one Subject and one Direct Object, each verb has an *Import* value associated with it that signifies how newsworthy the verb might be (a component of information sharing between actors). In Crawford's "storyworlds", the events that make up the player's story-experience are determined collaboratively by autonomous non-player characters (NPCs) through their reactions to situations and the actions of other characters. When an action is performed, author-specified roles for potential reactive behaviours are advertised to nearby NPCs, and as soon as an NPC is found that satisfies a set of conditions for taking on a role, that NPC will choose a reaction to perform from those specified by the role's behaviour. Each NPC's choice of a reaction is based on vectors of values that model both their own personality and their perception of the personality of other characters.

To help guide the NPCs in a storyworld to take dramatic actions, Crawford suggests defining a set of overview variables that are used to monitor certain properties of the storyworld and influence the behaviour of its actors. For example, the Import values of all recent events could be used to recognize when the story is becoming dull, and trigger Fate to set a more exciting event in motion. Table 3.3 shows the story decision properties for Crawford's work for the "Rescue from Fire" event.

Player input in both The Erasmatron and Storytron is handled through an innovative graphical sentence construction tool that provides players with a large number of potential actions while ensuring that no player action can be entered incorrectly or misinterpreted by the system. Player feedback is acquired through the player's actions as influences to the personalities of the storyworld's NPCs; in Crawford's game *Trust and Betrayal*, lying to other characters too frequently will have a negative impact on their perception of the player's personality, and make them less willing to share information as a result [32].

| | Decider | Time | Method | Justification |
|---|---|---|---|---|
| *Idea* | Author | Online | Find High-Import Event | Maintain Story Excitement |
| *Actors* | Author | Online | Reactive Behaviours - Given that the verb "Fate put Fred in danger using Fire" has just occurred, it will advertise reactive behaviours to nearby actors, perhaps including a "Friend" behaviour requiring two actors to fill its roles (one being a friend of the other). John would see this advertisement and take on the "friend" role. | Allow Flexible Collaborative Behaviours |
| *Time* | Author | Online | Overview Variable: Total Import - After recognizing that the storyworld's recent events had become dull, Fate elected to start a fire to create some excitement. | Maintain Story Excitement |
| *Place* | Author | Online | Find Actors - To initiate the Rescue event, Fate might have examined each of the storyworld's stages and chosen one that had at least two actors present. | Obtain Required Actors |
| *Actions* | Author | Online | Behaviour Action Selection - When John takes on the "friend" role in the "Rescue" behaviour, his AI examines the potential courses of action that the author has specified (*e.g.* Rescue, or Flee), and chooses the most appropriate based on his own personality model and his perception of Fred's (*e.g.* "*I'm a nice guy, and Fred's a nice guy, so I should rescue him*"). | Ensure Personality-consistent Behaviour |
| *Motives* | Author | Offline | Imagination | No Restrictions |

Table 3.3: Story decision properties for Crawford's work.

**FearNot! - Fun with Empathic Agents Reaching Novel Outcomes in Teaching**

As an experiment in creating educational anti-bullying software for children, Aylett *et al.* created *FearNot!*, a system for generating emergent narratives through the interactions of emotionally-driven, intelligent, non-player characters [3]. Author knowledge in *FearNot!* is represented as a set of rules that the characters use to appraise their emotions in response to sensory perceptions, and as a set of links between goals that the characters may pursue.

Figure 3.1: Screen capture from *FearNot!* (c.f. [3]).

Story action is conveyed to the user using 3-d animation (Figure 3.1), and player feedback is acquired in between scenes of action, using the premise of a victim of bullying asking the player for advice with his problem. The player suggests a way for the actor to behave by typing natural language text, which alters the actor's emotional state and thus its willingness to pursue potential goals in later scenes (*e.g.* a suggestion of "fight back" makes the actor less fearful of the bully). Table 3.4 shows the story decision properties for *FearNot!* for the "Rescue from Fire" event.

| | **Decider** | **Time** | **Method** | **Justification** |
|---|---|---|---|---|
| *Idea* | Author | Online | Brave Actor - Through player advice, John might have been encouraged to behave more bravely, resulting in his deciding to choose rescuing Fred as a goal to pursue. | Respond to Player Feedback |
| *Actors* | Player & Author | Online & Offline | Encouragement & Scripting - By encouraging John to act, the player determines John's involvement in the event. Supposing that the goal of the story was to teach fire safety, the author may have pre-determined that Fred would need to be rescued. | Respond to Player Feedback, and Achieve Educational Goals |
| *Time* | Author | Offline | Imagination | No Restrictions |
| *Place* | Author | Offline | Imagination | No Restrictions |
| *Actions* | Author | Online | AI Planning - given John's goal to rescue Fred, he would automatically determine that carrying Fred outside was an appropriate action to take. | Goal Satisfaction |
| *Motives* | Author | Offline | Imagination | No Restrictions |

Table 3.4: Story decision properties for *FearNot!*.

**Limitations of Simulation**

Although Simulation helps a great deal in improving the believability of a story's characters and environment, it is not without limitations. For one, there is typically nothing to ensure that the resulting story will have global structure (Story Property 2). Furthermore, in Simulation-based systems, it is difficult for authors to know exactly when and why a particular event might occur; the collaboration of multiple autonomous characters can quickly become too complex for an author to easily predict. In fact, neither Crawford's systems nor Aylett *et al.*'s *FearNot!* are based purely on Simulation; both include some method of guiding the actions of their characters, either through story overview variables that influence their decision-making, or by directly assigning actions to bring about the opening or closing of the story. In addition, the latest release in the *Sims* franchise is *The Sims Life Stories*, wherein global story structure is added by constraining the behaviour of the non-player Sims to force the player along a sequence of pivotal life events (*e.g.* gettting a job, finding a spouse, having a baby) in addition to the usual *Sims* gameplay [28]. At present, there is no known method for achieving both strong global story structure and a transparent authoring process[1] without employing some system to manage the player's experience.

[1] A *transparent authoring process* is a means of creating events for an interactive story in which it is readily apparent both when and why each event might occur.

### 3.1.4 Experience Management

Throughout the literature, systems for guiding a player's experience in a story have been given many names; *drama manager*, *story director*, and *virtual storyteller* are all commonly used. Following Riedl and Stern [45], I use the term *experience manager*, as its generality makes it descriptive of most relevant techniques in Interactive Storytelling.

Much like the director of a motion picture, experience managers act as an intermediary between the author of a story and its audience. By the time a story reaches its audience, every detail must be completely specified - every storytelling decision must have already been made. When a story reaches the director of a typical motion picture, only a few story decisions remain; the details of *Idea*, *Actors*, *Time*, *Place*, and *Motives* have all been fully specified by the author. The finest details of *Actions*, however, have been deferred to the director (*e.g.* how an actor moves across a scene or speaks to another actor). This deferral is only possible because the director has been trained in his craft, possessing the knowledge that is necessary to make his decisions well. Unfortunately, as a paradigm for Interactive Storytelling, this Author-Director-Audience model is insufficient; the director's training is independent from the author, (leading to potential conflicts of style), and the director has no interaction with the audience (Figure 3.2). These problems lead to the one-size-fits-all approach to storytelling that I argued against in Chapter 1.

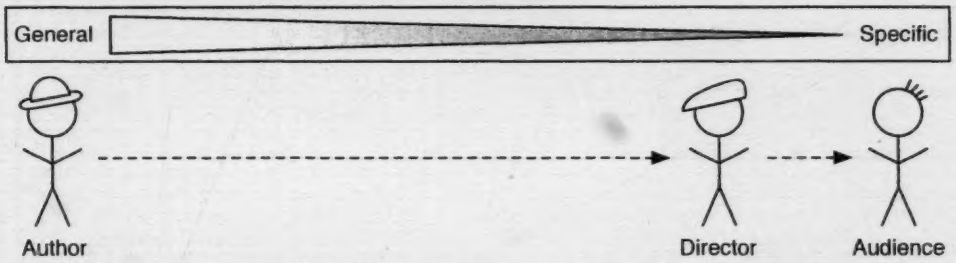


Figure 3.2: The Author-Director-Audience model for Interactive Storytelling. The author, director, and audience are all independent, the director makes relatively few story decisions, and there is no opportunity for the audience to influence their experience.

In commercial video games, Experience Management through a director is a commonly used technique, resulting in the linear and branching strategies for storytelling that I discussed in Section 1.6. With both of these strategies, the author of the story encodes a small amount of knowledge into an experience manager (*e.g.* the behaviours of AI opponents, or the results of player choices for branching story content), and the manager interacts with a player reactively to convey one of the several stories that could result (recall reactive interactivity from Section 2.1.1). Given that this type of experience manager makes very few story decisions relative to the author, I refer to it as a director instead (Figure 3.3).

To manage a player's experience, an experience manager must make a significant number of storytelling decisions; to do so, a significant amount of author knowledge must be obtained. Like

the strategies in commercial video games, many experience managers interact with their players reactively and base their storytelling decisions on author-supplied information instead (Figure 3.4).

In the following sections, I discuss several Interactive Storytelling techniques which are *player-informed*, *i.e.*, they base their storytelling decisions on feedback gathered from the player (deliberative interactivity). Portions of these sections appear in revised form in my forthcoming publication [51]. Like the work that I present in this dissertation, the techniques that I discuss aim to expand the decision-making capabilities of typical video game story directors to allow an experience manager to interactively tell a much richer set of personalized, interactive stories (Figure 3.5).

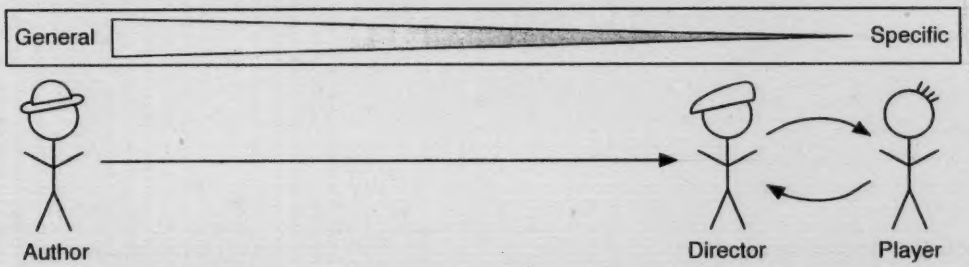


Figure 3.3: The Author-Director-Player model for Interactive Storytelling. The author supplies a small amount of knowledge to the director, the director makes relatively few story decisions, and the director conveys the story while receiving and reacting to player feedback (reactive interactivity).

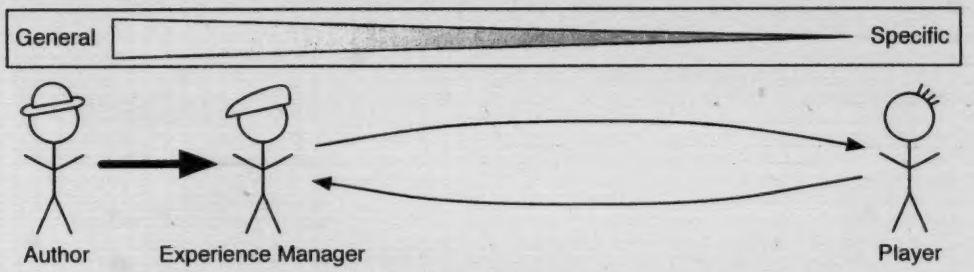


Figure 3.4: The Author-Manager-Player model for Interactive Storytelling with reactive interactivity. Leveraging a large supply of author knowledge, the experience manager makes many story decisions and conveys them to the player, while receiving and reacting to player feedback.

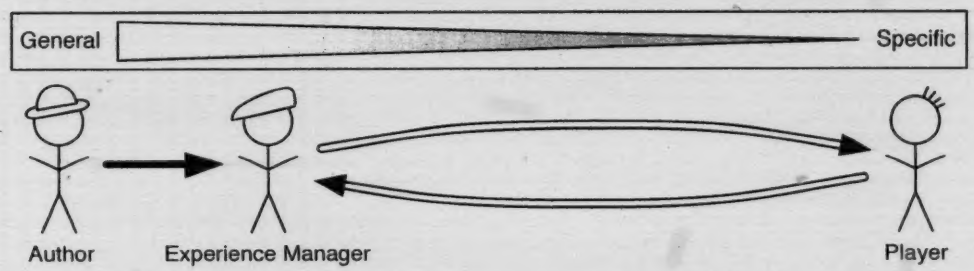


Figure 3.5: The Author-Manager-Player model for Interactive Storytelling with deliberative interactivity. Leveraging a large supply of author knowledge and immediate player feedback, the experience manager makes many story decisions based on the feedback obtained from each player.

**Façade**

Released to the public by Procedural Arts in 2005, *Façade* is a "fully-realized, one-act interactive drama", created by Mateas and Stern as an art and research experiment in Artificial Intelligence and Interactive Storytelling [36]. In *Façade*, author knowledge is represented in the form of a set of dramatic *beats* (with preconditions) and a set of desired *story value* trajectories; beats are defined to be the smallest unit of dramatic action (*e.g.* a quizzical stare), and story values represent aspects of the story which can be either manipulated directly by the player, or adjusted automatically by selecting beats to achieve a desired trajectory over the course of the story (*e.g. Tension* is a value that could be used to specify a traditional dramatic arc) [20]. Events are selected by a probabilistically-weighted, priority-based algorithm, which operates by modifying the probability of selecting each event based on both the current state of the storyworld and the author-specified effects that the event will have on the story values that are being maintained. If an event with satisfied preconditions will bring the manager's story values along the trajectories that were specified by the author, then its selection probability will be increased; *Façade* uses tension as a story value with a trajectory that approximates a dramatic tension arc.

Figure 3.6: Screen capture from *Façade* (c.f. [20]).

*Façade*'s story is conveyed via 3-d animation in a small, virtual world, in which two non-player characters (NPCs) communicate with each other and to the player via audible speech (Figure 3.6). Player feedback is captured through typed, natural-language text (*e.g.* "Grace, I like the armoire."), movements in the storyworld (*e.g.* walking into the kitchen), and interactions with various objects (*e.g.* picking up a photograph). Throughout the story, a model of the player is maintained which tracks her affinity with the two NPCs. The affinity value is zero-sum; if the player's actions result in her holding a positive affinity with one NPC, then the model assumes that her affinity with the other NPC is negative. This behaviour is supported within the premise of the story, as the two NPCs repeatedly argue and encourage the player to support one of their positions. *Façade* uses affinity as a story value to heighten player agency; for example, if she maintains positive affinity with one of

the NPCs for several minutes, then events that reveal that NPC's past will become more likely to occur. Table 3.5 shows the story decision properties for *Façade* for the "Rescue from Fire" event.

| | Decider | Time | Method | Justification |
|---|---|---|---|---|
| *Idea* | Author | Offline | Imagination | No Restrictions |
| *Actors* | Author | Offline | Imagination | No Restrictions |
| *Time* | Author | Online | Tension Arc - The tension arc supplied by the author may have recently increased sharply, prompting the experience manager to sequence an event with a high tension effect. | Follow Dramatic Principle |
| *Place* | Author | Offline | Imagination | No Restrictions |
| *Actions* | Player & Author | Online & Offline | Interruptible Scripts - High-level actor behaviours are pre-determined, but are authored in a way that they can handle player interruptions and then resume the original behaviour. | Allow Player Interaction |
| *Motives* | Author | Offline | Imagination | No Restrictions |

Table 3.5: Story decision properties for *Façade*.

**The Interactive Drama Architecture**

In Magerko's Interactive Drama Architecture (IDA), author knowledge is represented as a partial ordering of *plot points* - events of the story having preconditions (to restrict the occurrence of the event), begin/end time constraints (marking an interval during which the preconditions must become satisfied), and a set of actions for the story's actors to perform during the event [19]. Preconditions can be authored generically through variables, to be specified automatically by the director at run-time (*e.g.* both John and Fred must be in the same location, $x$, but $x$ is left undetermined until the story is told). Plot points in IDA are selected as follows: when a point's 'begin' time constraint is satisfied, the point is marked as being *active*. Giving preference to points with satisfied preconditions that involve the player, an active plot point is selected to perform. For the selected point, IDA automatically fulfills any preconditions involving only non-player characters (NPCs) by directing those characters to satisfy those preconditions (*e.g.* sending an NPC to move near the player).

IDA also executes two other types of direction: reactive and pre-emptive. Reactive direction occurs when the player (either through action or inaction) violates the 'end' constraint of a plot point or renders the precondition of an unused plot point impossible to satisfy (*e.g.* by destroying a book containing vital information). In the former case, the director might trigger an NPC behaviour that encourages the player to satisfy the precondition; in the latter, the director might create a new copy of the book elsewhere in the storyworld. Pre-emptive direction occurs based on a predictive model of what the player might do next; the goal of this approach is to predict when the player will violate a constraint or precondition (Magerko calls such violations *boundary problems*) and take some action to pre-emptively avoid the violation. For example, if IDA predicts that the player will not move near a particular NPC in satisfaction of a current plot point, then that NPC can be pre-emptively directed to move to a location near the player instead.

Figure 3.7: Screen capture from *Haunt 2*, testbed for the Interactive Drama Architecture (c.f. [19]).

IDA's stories are presented via *Haunt 2* (Figure 3.7), a 3-d virtual environment in which the player controls the ghost of a recent murder victim (the premise of the story is to discover the circumstances surrounding the victim's death). Player feedback is gathered exclusively through player movement and limited object manipulation; based on this feedback, a model of the player's knowledge concerning the story is maintained (*e.g.* when the player enters a room, IDA assumes that she knows that the room and its occupants (NPCs) exist, and that the room and occupants have particular observable features). Along with an author-defined model of a general player's goal-choosing tendencies (where goals include exploring the environment, following NPCs, or manipulating objects), IDA uses its inferred player knowledge to predict and avoid potential boundary problems. Table 3.6 shows the story decision properties for IDA for the "Rescue from Fire" event.

| | **Decider** | **Time** | **Method** | **Justification** |
|---|---|---|---|---|
| *Idea* | Author | Offline | Imagination | No Restrictions |
| *Actors* | Author | Offline | Imagination | No Restrictions |
| *Time* | Author | Online | Satisfied Preconditions - preconditions for this event might have been for Fred to be inside the building, with John and the player standing outside, and the building being on fire. | Use Available Plot Point |
| *Place* | Author | Online | Generic Preconditions - The location of the fire may have been left as a variable by the author, allowing IDA to select the building that Fred is in to satisfy one of the event's (generic) preconditions. | Allow Plot Point Flexibility |
| *Actions* | Player & Author | Online & Offline | Scripted Behaviour with Reactive/Pre-emptive Direction - pre-scripted actions occur unless the player causes (or is predicted to cause) a boundary problem, at which time reactive or pre-emptive direction occurs. | Preserve Story Coherence |
| *Motives* | Author | Offline | Imagination | No Restrictions |

Table 3.6: Story decision properties for the Interactive Drama Architecture.

### Mirage

In Mirage, player actions are parsed by a rule-based system to build a profile of the personality being portrayed by the player through her in-game avatar [38]. Author knowledge is represented as a set of rules that associate author-anticipated player behaviours with adjustments to the personality profile, which is maintained as a vector across five character traits: <reluctant hero, violent, self-interested, coward, truth-seeker>. Like Façade, Mirage uses its learned player data to affect the selection priority of narrative events: given an author's specification of how each event's priority should be altered based on the portrayed personality profile, Mirage automatically determines the priority of all available events, and chooses the event with the highest priority. In addition to modelling the player character's personality, Mirage tracks the player's cursor movements in an attempt to gauge both her inclination to choose an action and the degree of her hesitation in doing so. Inclinations toward actions are used to prompt behaviour changes in non-player characters (such as blocking the player from leaving a room - see Figure 3.8), and hesitation measures are used to regulate the magnitude of adjustments made to the personality profile. Although Mirage informs several parts of its storytelling process with player information, like Façade, it remains targeted toward players who appreciate a well-crafted drama. As I motivate in Section 4.1.2, dramatic tension is only one of the many sources of enjoyment that different types of players might seek.

Figure 3.8: Screen capture from *Mirage* (c.f. [38]).

### Case-Based Reasoning Approaches

Following David Kiersey's theory of temperaments, Gómez-Gauchía and Peinado attempt to automatically customize the behaviour of their narratives' NPCs using a Case-Based Reasoning approach [14]. Before the game begins, players fill out a questionnaire; applying Kiersey's theory to the result then indicates their temperament as a proportional combination of four basic types (*e.g.* <artisan: 20%, guardian: 50%, idealist: 10%, rational: 20%>). Given a knowledge base of dialogue and behaviour variations designed for several player temperaments, Gómez-Gauchía and Peinado's system selects the variation whose associated temperament most closely resembles the current player's. Variations include altering the politeness of the NPC's comments and the speed of

the NPC's movements. If the proportions of the selected variation's four basic types fail to match the player's temperament exactly, the system adapts the variation by further adjusting both dialogue politeness and NPC movement speed within restricted ranges. Although the modelling process of Gómez-Gauchía and Peinado's system is independent of the player's actions in-game, one can envision an extension in which a Kiersey-inspired questionnaire could be encoded within the narrative's events, allowing the more seamless technique of learning the player's temperament on-line.

In recent work, Sharma *et al.* extended Nelson and Mateas's work in Declarative Optimization-based Drama Management to incorporate the modelling of player preferences [48, 43]. Through a post-game player survey, ratings were obtained for their overall interest in the presented narrative, their interest in each of the narrative's individual events, and their degree of confidence in each of the ratings that they gave. By combining the feedback from each play with a trace of its narrative events, Sharma *et al.*'s player model creates a set of cases for a Case-Based Reasoning system, which is used by their drama manager in associating the current player's trace of events with interest ratings for potential future events. Subsequent events are selected via an expectimax search to maximize both a set of predefined author interests and the model's estimated player interests. While Sharma *et al.*'s work is strongly directed toward informing storytelling with player information, their dependence on a preexisting case base of player interests limits their flexibility in a commercial setting, post-release. Instead of relying on gathering enough pre-release feedback to sufficiently inform the model (or perhaps distributing post-release feedback via the Internet), it is more desirable to acquire and use the player's feedback *while* they play, independent of other players' data (Section 4.1).

**Dilemma-based Interactive Narratives**

Similar to Sharma *et al.*'s technique of optimizing for player interests, Barber and Kudenko's recent work presents a narrative planner designed to bring about social dilemmas that are expected to be of high interest to the current player (*e.g.* betraying a friend to achieve great personal gain) [6]. Set in the context of an interactive soap opera, their system models the player as numerical values across several personality traits: <honesty, faithfulness, selfishness, *etc.*>. The model is updated via author-assigned value adjustments that are attached to each dilemma choice (*e.g.* +1 honesty, -1 selfishness), and it is used to predict which choice the player will most likely select when presented with a particular dilemma. Given a set of author-defined interest values for each dilemma's choices, the system uses the model's prediction to select the dilemma that maximizes the likelihood of having an interesting outcome for the current player. Barber and Kudenko's work is very near to fitting my definition of Player-informed Interactive Storytelling; while it succeeds in both learning and using player feedback on-line, its use of single, general values for the expected interest of dilemma choices neglects the fact that players with different personalities will likely have different levels of interest in each dilemma choice. Estimating the interest value of each choice for various personality models is reflected in part of my approach (Sections 4.4.1 and 4.8.3).

## Summary

In this chapter, I identified five properties of the decisions that must be made when determining a story's events; namely, the result of the decision, the identity of the agent who made it, the time at which it was made, the method that was used to make it, and the reason why it was made in the way that it was. I identified two general strategies for Interactive Storytelling: Simulation, and Experience Management, and further characterized Experience Managers by the form of interactivity that they support: reactive, or deliberative. Finally, I used the identified story decision properties along with the core components of Player-informed Interactive Storytelling to discuss the eight elements of related work that are most related to the approach that I present in this work.

# Chapter 4

# Proposed Approach

In this chapter, I present PaSSAGE (Player-Specific Stories via Automatically Generated Events), the player-informed interactive storytelling AI that I designed, implemented, and tested as the focus of this work.

The following sections are organized as follows. I begin by providing an overview of how PaSSAGE approaches achieving the primary goals of storytelling toward telling good interactive stories (Sections 1.1 and 1.2), including several ideals that I chose to adopt in approaching PaSSAGE's design. Following this overview, the remainder of the chapter explains how PaSSAGE implements the core components of Interactive Storytelling AIs that I described in Section 2.3.

## 4.1 Introduction to PaSSAGE

PaSSAGE is an interactive storytelling AI that I designed to address the challenges of Player-informed Interactive Storytelling (Section 2.2). As I suggested in Section 1.7, deferring author decisions to run-time in a way that incorporates player feedback is an important step toward alleviating the problems of both Traditional Storytelling and the storytelling strategies of typical video games. The reason why this is so is as follows. Given the wide range of personalities, preferences, and interests across the set of potential players of a story, having a single story appeal to every one of these players is extremely unlikely; some may prefer a topic that others find undesirable. If, however, authors had access to each player's preferences while they were writing their stories, then the story given to each player could be customized to her tastes, avoiding undesirable topics and concentrating on those for which she had indicated some preference. Even so, each player's preferences may well change throughout the course of the story, making a foreknowledge of her preferences insufficient. Deferring author decisions to run-time provides access to the player's *current* preferences (through player feedback) *while* the decisions are being made, allowing the content of an interactive story to be dynamically adapted to suit the current, particular tastes of each individual player.

### 4.1.1 Primary Contribution to Interactive Storytelling

The primary contribution of PaSSAGE as an interactive storytelling AI is that the stories that it tells are *player-specific*; by automatically observing the storyworld actions that players take while they experience an interactive story, PaSSAGE builds a model of their preferred style of play, and then leverages the knowledge of the storyworld's authors to dynamically select subsequent events which allow the player to play in the modelled style. With this design, I hypothesized that PaSSAGE would be able to interactively create interactive stories that achieved the primary goals of storytelling, supposing that:

1) Customizing the content of a story to the preferences of its player would make the story more enjoyable (toward Goal 1: Maximize Enjoyment);

2) Choosing the story's content based heavily on the actions of its player would provide a higher sense of agency (toward Goal 2: Maximize Agency); and

3) Choosing the story's content based heavily on the actions of its player would increase the replay value of the story (by promoting different actions on subsequent plays) (toward Goal 3: Maximize Replay Value).

### 4.1.2 Styles of Play

Following Peinado and Gervás, I chose to base PaSSAGE's player model on Laws' set of player types for pen-and-paper role-playing games [44, 18]. In such games, one particular player, designated "Game Master", is responsible for directing the course of a story that all of the players experience; in his work, Laws' suggests that to improve the game experiences of their players, Game Masters should model each player's tendencies toward seven different styles of play, and choose the events of their stories to satisfy the types of players who are present. Table 4.1 lists Laws' types of players alongside summaries of what he expects each type of player to enjoy.

| **Player Type** | **Enjoys** |
|---|---|
| Fighter | Engaging in combat |
| Method Actor | Having her personality tested |
| Storyteller | Considering new plot threads |
| Tactician | Solving problems through thought and skill |
| Power Gamer | Acquiring special items, riches, and abilities |
| Specialist | Performing the skills that define her particular character |
| Casual Gamer | Socializing with the other players |

Table 4.1: Summary of Laws' player types for pen-and-paper role-playing games.

In designing PaSSAGE's player model, I decided to treat players as mixtures of the first five of Laws' types as given in Table 4.1. I removed the Specialist type because it focuses strongly on a large number of divergent types of *game characters* (*e.g.* ninja, wizard, bard), and differentiating between between these types during learning and event selection is a challenge that remains as future

work. I removed the Casual Gamer type because in a single player game, there are no other players with which to socialize (see Section 2.4.1)[1].

### 4.1.3 Events as Encounters

To focus the scope of this work, I elected to concentrate PaSSAGE's selection of story events on a particular subset of those which could potentially occur. Specifically, PaSSAGE selects *encounters* - events in the story which directly involve the player. Given that most commercial video games tend to focus their stories' events on the life of the player's character, having PaSSAGE choose only the encounters of a story (as opposed to all events) should not diminish the usefulness of my approach.

### 4.1.4 The Hero's Journey

To allow PaSSAGE to tell stories with strong global structure (Story Property 2), I decided to use the phases of Campbell's MonoMyth or *Hero's Journey* [9] as templates for PaSSAGE's encounters, and base PaSSAGE's selection of encounters on progressing through the cycle of phases that forms the Hero's Journey (Figure 4.1). Although Campbell's original intent in devising the Hero's Journey was to communicate the cross-cultural similarities that exist in all human mythology, it has been used prescriptively to create extremely successful stories, including the *Star Wars Trilogy*, and *The Matrix Trilogy* [52, 53]. Table 4.2 provides a brief description of each phase of the Hero's Journey.

| **Phase** | **Description** |
|---|---|
| Home | The journey begins at the hero's home. |
| Call to Adventure | An event occurs that prompts the hero to leave home and venture out into the world. |
| Reluctant Hero | The hero may be unwilling to depart on the adventure. |
| Supernatural Aid | The willing hero receives gifts to aid in his journey, and the unwilling hero is forced to leave by unexpected events (*e.g.* his home might be destroyed). |
| Crossing the Threshold | The hero crosses a threshold between his usual safe, familiar environment and the unfamiliar world outside. The hero is often tested at the threshold by some form of guardian. |
| The Belly of the Whale (Trials) | The hero faces and overcomes a set of challenges. |
| Allies and Enemies | The hero meets characters who may help or hinder him. |
| Ordeal | The hero confronts a villain, arising either from within (*e.g.* personal struggle), or without (*e.g.* a villainous character). |
| Seizing the Sword (Gift) | The hero gains rewards from having overcome the confrontation with the villain. |
| Flight (Road Back) | If the hero failed the confrontation with the villain, he must flee. |
| Master of Both Worlds (Rebirth) | The hero is tested for the final time, and allowed to return to the safe, familiar environment that he left. |
| Return with Elixir | The hero returns to his home with the rewards gained along his journey. |

Table 4.2: Descriptions of the phases in Joseph Campbell's Hero's Journey.

[1] An investigation whether casual gamers find socializing with non-player characters in the game to be an acceptable substitute to inter-player socialization remains as future work.

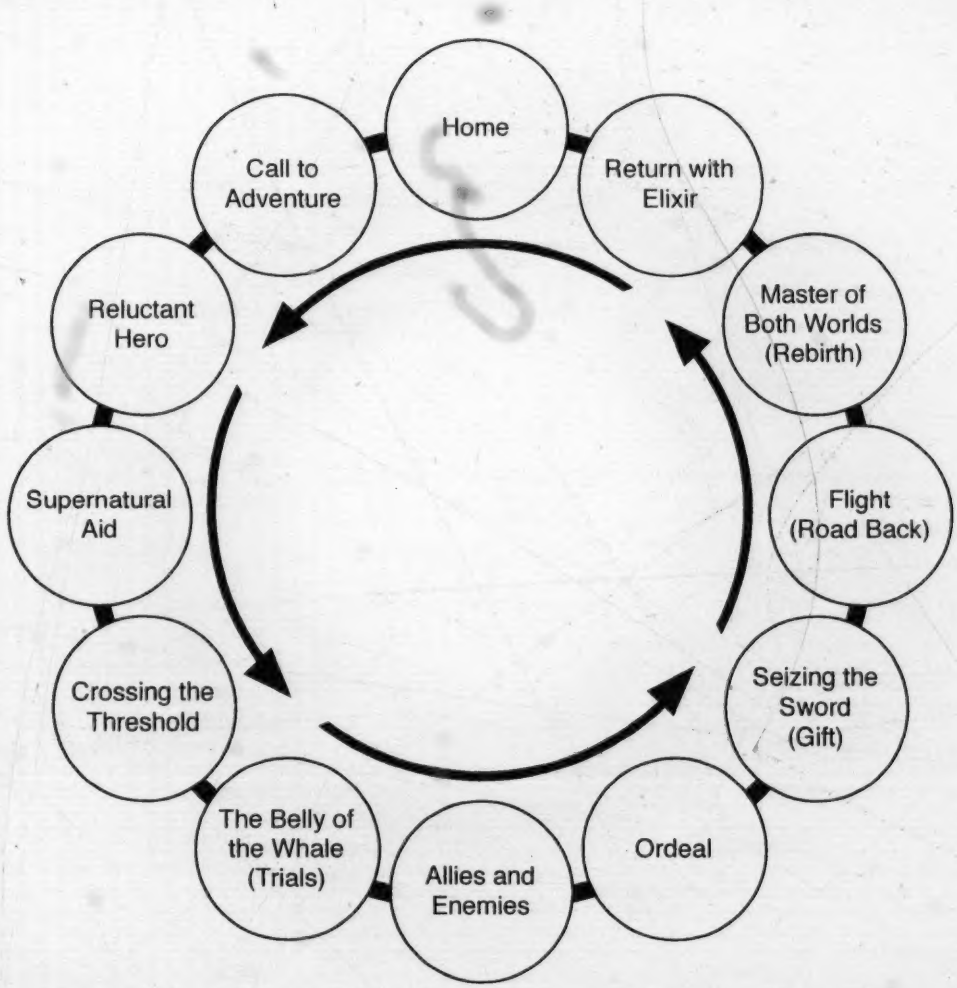


Figure 4.1: Joseph Campbell's Hero's Journey (based on similar figures found on the Internet [33]). Each phase represents a different type of event that often occurs in a heroic adventure.

### 4.1.5 Design Ideals

While designing PaSSAGE, I adopted the following ideals concerning both its operation and its usability for story authors, toward addressing the concerns that arose during discussions of my plans with friends and colleagues in both academia and the video games industry.

**Operational Ideal 1: The Reuse of Authored Content**

One concern that I noted early on during my design was that PaSSAGE's ability to customize stories to the preferences of its players would depend heavily on having a large set of encounters to choose from. To help mitigate this problem, I adopted the ideal of having PaSSAGE be able to *reuse* authored content by supporting the authoring of encounters that are *generic* (*i.e.*, not all of their properties are specified), and including a mechanism to automatically decide on the needed details

at run-time (see Section 4.5.2). This ideal also supports my intention to defer author decisions to run-time and base them on gathered player feedback.

**Usability Ideal 1: Simple Encounter Creation**

Also toward solving the problem of obtaining a large library of encounters, I aimed to design PaSSAGE's authoring process in such a way that made it easy to create and add new encounters to an existing storyworld, with the hope of one day having the *players* of a PaSSAGE-enabled game create and share encounters collaboratively over the Internet. Electronic Arts has demonstrated the potential of redistributing player-created content as new elements of a commercially released game (*SimCity 4*), with over 1500 contributors having created over ten thousand elements of content, downloaded over 24 million times at the time of writing [39]. The software tool that I used to implement PaSSAGE (BioWare Corp.'s Aurora Neverwinter Toolset [7]) was distributed as part of the commercial release of *Neverwinter Nights* [25], and Obsidian Entertainment recently set a precedent with *Neverwinter Nights 2* [35] by releasing its authoring tools to the public weeks *before* the game itself could be bought. This action is particularly encouraging in that with a similar production and publishing model, PaSSAGE's encounters could be created by the public, evaluated by professional authors, and included as part of a game's commercial release.

**Usability Ideal 2: A Transparent Authoring Process**

Commercial game companies have traditionally been reluctant to include adaptive technology in the games that they release, fearing that an unexpected adaptation could ruin the player's enjoyment of their game[2]. Given that PaSSAGE is ultimately an adaptive storytelling system, I adopted the ideal of having the authoring process for PaSSAGE's encounters be *transparent*; that is, it should always be readily apparent both when and why a given encounter might occur.

## 4.2 General Architecture

Figure 4.2 shows PaSSAGE's general architecture, including the general system modules (the Encounter Manager, the Game Engine, and The Player Model), the data that each module provides to (or receives from) the other modules and the player (Actions, Model Updates, Model Values, Encounters, and Audio/Video), and the points within the architecture at which the five challenges of Player-informed Interactive Storytelling are satisfied (Gather, Interpret, Relate, Decide, and Convey - see Section 2.2). The Encounter Manager is responsible for storing the encounters that are available to choose from, tracking which encounters are currently running, and deciding which new encounters should occur based on relationships between the values in the Player Model and author-supplied preference annotations concerning each of the available encounters. The Game Engine is responsible for maintaining the state of the storyworld (*e.g.* the geometry of the environment, the

[2] *Black & White*, *Fable*, and various recent games using auto-dynamic difficulty adjustment (*e.g. SiN: Episodes*) are notable exceptions [29, 30, 37].

properties of the actors, *etc.*) and managing the player's interactions with both the storyworld and the Encounter Manager; interactions with the storyworld are managed through reactive interactivity (*e.g.* clicking to open doors, converse with characters, *etc.*), and interactions with the Encounter Manager are handled using deliberative interactivity through the Player Model (see Section 2.1.1). The Player Model tracks the current estimate of the players' preferences, based on updates received from the Game Engine as a result of player actions.

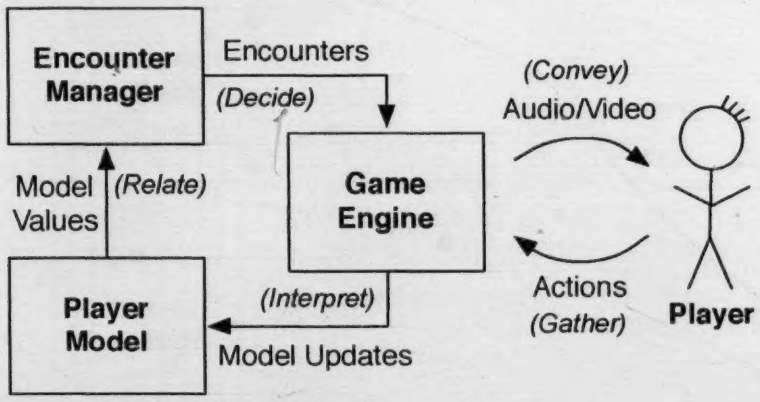


Figure 4.2: PaSSAGE's general architecture. Bold text shows the player and the general system modules, regular text shows data communication, and italic text shows where each of the five challenges of Player-informed Interactive Storytelling are met.

With reference to the five core components of player-informed interactive storytelling AIs, the Encounter Manager includes *Event Selection*, the Game Engine includes *Event Presentation*, *Input Handling / Feedback Acquisition*, and *Player Modelling* (it provides the updates to the Player Model), and *Knowledge Representation* is distributed across all three modules.

## 4.3 General Implementation

To implement PaSSAGE's architecture, I required a game engine to manage the presentation of PaSSAGE's stories, to handle player input and acquire player feedback, and to use the author's playstyle annotations on player actions to maintain the Player Model. I used BioWare Corp.'s Aurora Neverwinter Toolset: a commercial-grade computer software tool for creating storyworlds and story events which runs on the game engine of *Neverwinter Nights*, a multi-award-winning computer role-playing game [7, 25]. Figure 4.3 shows a screen capture of the Aurora Neverwinter Toolset. On the left-hand side of the figure, a list of the storyworld's environments (*areas*), actor conversations, and program scripts can be seen. To its immediate right is a manipulatable, 3-dimensional view of the current storyworld area. In the top right corner is the conversation editor, which allows conversations for one or many characters to be constructed as connected graphs of textual phrases. In the bottom right corner is the script editor, which allows program code to be entered in NWScript, a scripting

language similar in style and functionality to a reduced subset of the C and C++ programming languages. In other parts of the editor, scripts written in NWScript can be associated with player actions and game events that the engine automatically captures while a player plays.

Figure 4.3: The Aurora Neverwinter Toolset [7]. At left: the storyworld editor. At top-right: the actor conversation editor. At bottom-right: the program script editor.

In the following sections, I use PaSSAGE's general architecture and implementation to discuss how it implements each of the five core components of player-informed interactive storytelling AIs, toward achieving the primary goals of storytelling while telling good interactive stories, in addition to supporting the design ideals of authored content reuse, simple encounter creation, and a transparent process of authoring.

## 4.4 Knowledge Representation

PaSSAGE's knowledge base consists of three types of elements: elements that were created by an author (*encounters*), elements that track the storyworld's progress (*storyworld state*), and elements that are learned by observing the player (*player model*).

### 4.4.1 Encounters

Author knowledge in PaSSAGE is maintained as a *library of encounters* which is divided into several *encounter sets*. Each encounter set is designed to correspond to a particular type of event in a generic global story structure. As I mentioned in Section 4.1.4, I chose the phases of Joseph Campbell's Hero's Journey as templates for PaSSAGE's encounters, but the events of any generic global story structure would suffice for this purpose.

Encounters are story events which directly involve the player. Within every encounter is a set of *branches* - potential courses of action for the player to take in response to the event. For example, considering an encounter wherein the player has just discovered the location where a suspected murderer is hiding, one course of action might be to attack the suspect directly, while another might be to engage him in conversation to learn his point of view. Each of these courses of action would be a *branch* of the encounter, and each such branch is annotated with the author's expectation of whether each of the five types of players (Section 4.1.2) would enjoy, be indifferent toward, or not enjoy taking the course of action that it entails. Table 4.3 shows potential annotations for the "Murderer in Hiding" encounter. The annotations are interpreted (in terms of the author's expectations) as follows: the Pre-emptive Strike branch would be greatly enjoyed by players who play as a Fighter, and it would also be enjoyed by Tacticians; players of other types would be indifferent to playing through this branch. The Conversation encounter would be somewhat displeasing to a Fighter, but greatly enjoyed by a Storyteller, and evoke indifference in players of the other three types.

| Player Action | Fighter | Method Actor | Storyteller | Tactician | Power Gamer |
|---|---|---|---|---|---|
| Pre-emptive Strike | ✓✓✓✓✓ | - | - | ✓✓ | - |
| Conversation | ×× | - | ✓✓✓✓✓ | - | - |

Table 4.3: Two branches of an encounter involving a murderer in hiding, with play-style annotations. Check marks indicate that the author expects that players of the given type will enjoy playing through the given branch (more check marks indicate greater expected enjoyment). Similarly, crosses indicate an expected aversion to playing through the given branch for players of the given type, and dashes indicate an expected indifference.

Following Operational Ideal 1 (The Reuse of Authored Content), PaSSAGE's encounters are *generic* and *reusable*, in that they leave the six properties of story events (Section 1.3) largely unspecified. To do so, however, extra author information is required concerning how PaSSAGE should determine the values of these properties while the story is being told. Table 4.4 summarizes how PaSSAGE defines the properties of each encounter, alongside the author information that is required to choose values for each particular property. The three types of information that are required, namely, *role passing conditions*, *triggers*, and *branch annotations*, are discussed with respect to how they are used in Sections 4.5.2 and 4.5.3. To allow authors to restrict the number of times that an encounter might occur during a particular story experience, each encounter contains a number that specifies this value.

| Event Property | Encounter Properties | Decision Information |
|---|---|---|
| *Idea* | Idea | Player Model |
| *Actors* | Generic Roles | Role Passing Conditions / Triggers |
| *Time* | Journey Phase and Moment | Role Passing Conditions / Triggers |
| *Place* | Generic Situations | Role Passing Conditions / Triggers |
| *Actions* | Hinting Alternatives | Branch Annotations |
| *Motives* | Motives | None (Future Work) |

Table 4.4: PaSSAGE's treatment of event properties as encounter properties toward making encounters generic and reusable. The rightmost column describes the extra author information that is required for PaSSAGE to decide a value for the corresponding encounter property.

### 4.4.2 Storyworld State

The state of PaSSAGE's storyworld is maintained by the Game Engine module, and includes properties such as the geometry of the storyworld's environments (*areas*), the properties of all its actors (*e.g.* appearance and ambient behaviours.)

### 4.4.3 Player Model

The values in the Player Model (which are described in detail in Section 4.8) are updated by the Game Engine in response to player actions that have been annotated by the storyworld's author as being indicative of particular player preferences. For example, choosing to attack an unknown, aggressive actor might indicate that the player is inclined toward the Fighter or Tactician styles of play, while engaging the actor in conversation might be indicate an inclination toward the Storyteller style of play. Assuming a Game Engine that supports detecting and responding to player actions through scripted program code (scripts), authors can add their annotations directly to the scripts that fire when the player takes the action that they wish to annotate. Figure 4.4 shows examples of the scripts that might be used for an encounter involving the unknown, aggressive actor described above, written in NWScript (Section 4.3).

## 4.5 Encounter Selection

Using the terminology that I introduced in Chapters 2 and 3, PaSSAGE is an *experience manager*; specifically, it follows the Author-Manager-Player model for Interactive Storytelling with *deliberative interactivity* (Figure 3.5). When supplied with the knowledge described in Section 4.4, PaSSAGE makes decisions concerning the selection of its stories' encounters and the properties thereof, based on its learned model of the current player's preferred styles of play. As I presented in my previous work, PaSSAGE treats Encounter Selection as the most general of three phases of decision-making: Encounter Selection, Encounter Specification, and Encounter Refinement [50].

Script: OnAttacked

```
1   void main()
2   {
3       pmChangeTypeValue(PM_FIGHT, PM_TYPE_HIGH);
4       pmChangeTypeValue(PM_TACT, PM_TYPE_LOW);
5
6       AssignCommand(OBJECT_SELF, ActionAttack(GetFirstPC()));
7   }
```

Script: OnConversation

```
1   void main()
2   {
3       pmChangeTypeValue(PM_STORY, PM_TYPE_HIGH);
4
5       BeginConversation(''aggressor_conv'');
6   }
```

Figure 4.4: Two example scripts showing how values in the player model are updated based on player actions, using an encounter involving an unknown, aggressive actor. The upper script would be attached to the "OnAttacked" event of the actor, while the lower script would be attached to the actor's "OnConversation" event. `pmChangeTypeValue` modifies the inclination toward the given type in the player model by the given value (*e.g.* the parameters `PM_STORY` and `PM_TYPE_HIGH` cause a substantial increase to the inclination toward the Storyteller type in the model.

### 4.5.1 Encounter Selection

In PaSSAGE's Encounter Selection phase, it decides a value for the first of the six properties of story events; that is, it answers the question: "*What should happen?*" Pseudocode for PaSSAGE's Encounter Selection algorithm is given in Figure 4.5. As input, the algorithm receives both the current phase of the Hero's Journey (as I described in Section 4.1.4) and the current values in the player model, clamped to be greater than or equal to zero (the reason for this operation will be discussed in Section 4.8.3). PaSSAGE begins by retrieving the encounter set for the current phase of the Hero's Journey, and initializing the variables that it requires to find the encounter having the highest *quality* (lines 1 through 4). Then, for each encounter in the retrieved encounter set, PaSSAGE does the following. It first checks to see if the encounter has exceeded the maximum number of times that the author has allowed it to be run; if so, PaSSAGE skips to the next encounter (lines 6 and 7). Otherwise, the set of the encounter's branches are retrieved (line 9). For each branch of the current encounter, PaSSAGE retrieves the author-supplied play-style annotations for that branch and computes the quality of the branch by assessing the similarity of its annotations to the values in the player model via an inner product calculation (high similarity implies higher quality - lines 11 and 12). If the current branch is either the first to be examined or its quality equal to or better than the highest-quality branch examined thus far, then the current branch is recorded as the new best branch, and the current encounter is recorded as the new best encounter (lines 13 to 16). Finally, PaSSAGE returns the encounter whose branch has the best quality, along with the identity of that branch (to be used in Hinting, as described in Section 4.5.3 - line 20). To break ties

arising from multiple branches having the same quality, I treated each encounter set and each set of branches as an ordered list, and randomized this order upon retrieving the set.

**Extensions**

In addition to the core functionality shown in Figure 4.5, I trivially extended PaSSAGE's Encounter Selection algorithm to allow both the search for an encounter to end early if a particular quality threshold was met, and the best branch of a particular encounter to be found.

**PaSSAGE: Encounter Selection**

```
Input: phase ← current phase of the Hero's Journey
       model_values ← clamped Player Model values
1   E ← GetEncounterSet(phase)
2   best_enc ← ∅
3   best_branch ← ∅
4   best_quality ← GetMinimumEncounterQuality()
5   for each encounter e in E:
6       if GetTimesRan(e) ≥ GetMaxTimesToRun(e) then
7           continue
8       end if
9       B ← GetBranches(e)
10      for each branch b in B:
11          annotations ← GetBranchAnnotations(b)
12          quality ← InnerProduct(annotations, model_values)
13          if quality ≥ best_quality then
14              best_enc ← e
15              best_branch ← b
16              best_quality ← quality
17          end if
18      end for
19  end for
20  return (best_enc, best_branch)
```

Figure 4.5: Pseudocode for PaSSAGE's Encounter Selection algorithm.

### 4.5.2 Encounter Specification

In PaSSAGE's Encounter Specification phase, it decides values for the second, third, and fourth of the six properties of story events; that is, it answers the questions: "*Who should be involved?*", "*When should it happen?*", and "*Where should it happen?*" PaSSAGE answers these questions using two technologies: Role Passing, and Triggers.

**Role Passing**

Role Passing is a technology that allows the behaviours of agents (in this work, the behaviours of actors) to remain independent of the agents themselves until the time at which the behaviours should be performed [16, 31]. For PaSSAGE, an author creates a generic set of roles for an encounter, such

as a *Murderer*, a *Victim*, and a *Witness*, by specifying the behaviours and dialogue that actors playing each of the roles should perform once the encounter is chosen to occur. The author additionally specifies a set of *role passing conditions*, which specify a set of restrictions to enforce concerning the properties of the actors who might take on each role. For example, consider an encounter in which a child has lost his or her parent. The author specifies a behaviour and dialogue for the child (*e.g.* wander aimlessly in an area asking for help, and ask the player for help if approached) and a behaviour and dialogue for the parent (*e.g.* wander an area in search of his or her child, and ask the player for help if approached), as well as a set of conditions that the actors must satisfy to take on the roles, such as (for the child) "*the actor must be a child, and he or she must be within 10 metres of the player's character (in the game environment)*", and (for the parent) "*the actor must be an adult, and he or she must be farther than 50 meters from the actor playing the role of the child*".

**Triggers**

Once an encounter has been selected to occur, it enters a state of being *cued*. For every encounter in this state, PaSSAGE uses the Game Engine to repeatedly assess the state of the storyworld, attempting to determine if actors are available that satisfy the conditions that were specified that encounter's roles. In addition, conditions for an encounter's execution may also be specified concerning the properties of inanimate objects in the world, such as the distance between the player and the nearest entrance of a building. I refer to such conditions as *triggers*, because as soon as they are all satisfied, the actors and objects that satisfy the conditions are reserved for the encounter, and the presentation of the encounter's events begins. Once the encounter terminates, the actors and objects are released, making them available to be used in subsequent encounters. If desired, the author can specify a time limit for each encounter being in the *cued* state; if this limit is exceeded, the encounters triggers will no longer be checked, and the encounter will not occur.

Figure 4.6 shows an example of PaSSAGE attempting to run the "lost child" encounter described above. In subfigure a), the encounter is *cued*; the highlighted child uniquely satisfies the conditions for playing the child in the encounter, but no adult is farther than 50 meters from this child. The encounter cannot yet run. Subfigure b) shows the result of the highlighted adult in subfigure a) moving to the indicated position; both the child and the adult now respectively satisfy the roles for the child (C) and parent (P) in the encounter, and the encounter begins with their assuming roles that were authored for them.

### 4.5.3 Encounter Refinement

In PaSSAGE's Encounter Refinement phase, it decides values for the fifth of the six properties of story events; that is, it answers the question: "*How should it happen?*" When an encounter with multiple branches is selected to occur, its highest quality branch is known (line 15 in Figure 4.5). One option at this point would be to restrict the player to playing in the manner indicated by this

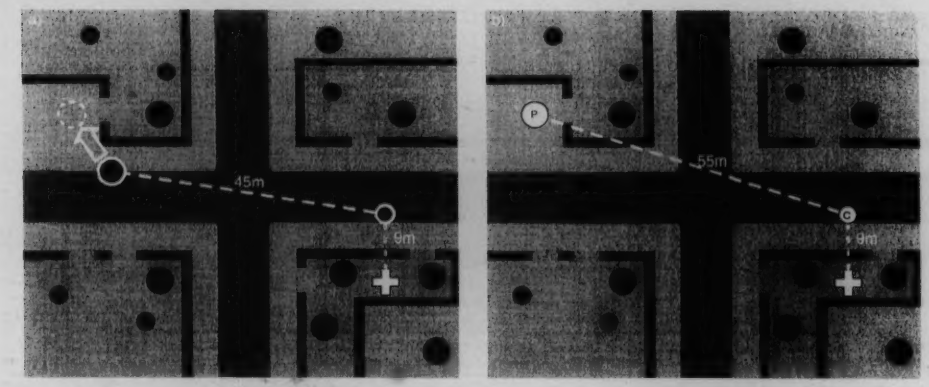


Figure 4.6: An example of PaSSAGE attempting to run the "lost child" encounter described in Section 4.5.2. Circles represent actors (small nodes are children), the plus sign represents the player, and solid lines represent the walls of buildings.

branch, but doing so could significantly hinder PaSSAGE's learning of the player model, as the player would be unable to perform an action that they might prefer over the one that PaSSAGE selected. To avoid this problem and provide more opportunities for learning the player model, I aimed to have every branch of a chosen encounter remain available for the player to play. However, this strategy brings up the problem of ensuring that the player becomes aware of the branch that PaSSAGE chose (hoping that it chose correctly). To address this problem, I introduce *hinting*; a technique for player direction wherein a particular encounter's branch is subtly bought to the player's attention as a potential course of action. For example, in the "lost child" encounter given above, the parent might hint at the chance of a reward for finding her child when approached by a player inclined toward being a Power Gamer. For a concrete example of hinting, see Section 5.3.3.

**Backup Motivations**

Backup Motivations are an additional component to Encounter Refinement that I introduced specifically for the Call to Adventure phase of the Hero's Journey. If the player expresses disinterest in the motivation for leaving home and embarking on an adventure, an alternative motivation will be presented; for example, if a player shows disinterest in going on a mission to help someone in need, then a promise of danger and combat along the way is made as a last resort. Future work aims to deliver multiple Calls to Adventure as necessary (using more than one encounter), but to date, associating one backup motivation with each Call to Adventure encounter has sufficed.

## 4.6 Encounter Presentation

As I mentioned in Section Section 4.3, PaSSAGE was implemented to use the game engine from *Neverwinter Nights* (NWN) [25]. As a result of this choice, the presentation of PaSSAGE's stories is restricted to the capabilities of this engine; namely, the player controls a single character in a 3-dimensional storyworld from a third-person view (*i.e.*, the player views the storyworld as though

through a camera floating above or near her character's body). From this perspective, the player experiences encounters as the actions of the storyworld actors that she encounters during the story. The actions that each encounter's actors take during the encounter are specified using NWScript; the resulting scripts are then interpreted by the NWN game engine to convey the actions on-screen.

## 4.7 Input Handling / Feedback Acquisition

Although PaSSAGE is player-informed (*i.e.*, it employs deliberative interactivity), it leverages the NWN game engine to employ reactive interactivity as well, toward handling the player's movement throughout the world, choices during conversations with the storyworld's actors, and actions during combat. As I discussed in Section 4.4.3, PaSSAGE acquires its players' feedback through author annotations on potential player actions. For all of the potential player actions in every encounter, author annotations inform PaSSAGE as to the player's preferred style of play by adjusting the values stored in the Player Model when the Game Engine intercepts the associated actions (see Figure 4.4). Such actions typically include dialogue choices during conversations with actors, combat, and the collection of game objects.

## 4.8 Player Modelling

As I have mentioned several times throughout this work, I view Player Modelling as being an essential aspect of Player-informed Interactive Storytelling. Using five of Laws' styles of play for pen-and-paper role-playing games (Section 4.1.2) [18], namely, *Fighter*, *Method Actor*, *Storyteller*, *Tactician*, and *Power Gamer*, PaSSAGE maintains a model of the player's play-style preferences as a mixture of these types.

### 4.8.1 The Player Model

For each style of play (*player type*), PaSSAGE keeps a unit-initialized, integer value whose magnitude indicates the model's expectation of the strength of the player's inclination to play in the given style (negative values indicate aversion or disinclination). For example, a player with the model <Fighter = 141, Method Actor = -41, Storyteller = 1, Tactician = 241, Power Gamer = 1> is expected to be strongly inclined toward playing as a Fighter or a Tactician, somewhat disinclined to play as a Method Actor, and indifferent toward playing as a Storyteller or Power Gamer.

### 4.8.2 Leaning the Model: Action Annotations

As I described in Section 4.4.3, PaSSAGE learns its model of the player by relying on the Game Engine to capture player actions and activate corresponding NWScript scripts. Each action's script holds the author's annotation of which style of play is indicated by that action, where the annotation

takes the form of one or more function calls to increase or decrease the values in the model (Figure 4.4). For example, a player action involving refusing an offered reward might indicate that the player is less of a Power Gamer, decreasing the corresponding value in the module by some amount (in my implementation, 40 is a small amount, while 100 is a large amount).

### 4.8.3 Using the Model: Branch Annotations and Clamping

As I mentioned in Section 4.5.1, PaSSAGE's Encounter Selection operates based on an inner product calculation between the values in the player model (clamped to be greater than or equal to zero), and the annotations on each branch of every encounter (Table 4.3). Figures 4.7 and 4.8 show examples of calculating the quality of an encounter having two branches (where check marks, crosses, and dashes have been converted to positive numbers, negative numbers, and zero, respectively). The difference between the two figures is that in the former, negative values in the player model are not clamped to zero, whereas in the latter, they are. The resulting branch selections demonstrate the need for the clamping process: in Figure 4.7, the quality of Branch 2 is incorrectly inflated by the combination of both the player not being a Method Actor and the branch's annotation of it not being enjoyable for Method Actors, and the quality of Branch 1 is incorrectly decreased; if the player does not play in a particular style, then providing them with that style of play, although likely of little use in terms of promoting their enjoyment, should not harm their enjoyment either. Figure 4.8 shows that clamping the model values to zero produces a more desirable branch selection.

| Player Type | Model Value | Branch 1 | Branch 2 |
|---|---|---|---|
| Fighter | 41 | 2 | 0 |
| Method Actor | **-141** | 2 | -2 |
| Storyteller | 1 | 1 | 2 |
| Tactician | 241 | 1 | 0 |
| Power Gamer | 1 | 2 | 4 |
| | **Branch Quality:** | 44 | **288** |
| | | **EncounterQuality:** | **288** |

Figure 4.7: Example calculation of encounter quality using branch annotations along with the values in the player model, without clamping the model values to be greater than or equal to zero.

| Player Type | Model Value | Branch 1 | Branch 2 |
|---|---|---|---|
| Fighter | 41 | 2 | 0 |
| Method Actor | **0** | 2 | -2 |
| Storyteller | 1 | 1 | 2 |
| Tactician | 241 | 1 | 0 |
| Power Gamer | 1 | 2 | 4 |
| | **Branch Quality:** | **326** | 6 |
| | | **EncounterQuality:** | **326** |

Figure 4.8: Example calculation of encounter quality using branch annotations along with the values in the player model, with model values clamped to be greater than or equal to zero.

## Summary

In this chapter, I presented PaSSAGE (Player-Specific Stories via Automatically Generated Events), the player-informed interactive storytelling AI whose design, implementation, and evaluation I led as part of a team of faculty and students at the University of Alberta. I provided an overview of PaSSAGE's operation, including the key concepts of styles of play, events as encounters, and using the Hero's Journey to provide global structure to an interactive story. I described and motivated a set of ideals that I aspired to while designing PaSSAGE, and explained both its high-level architecture and my process of implementation. Finally, I provided details and examples of how PaSSAGE implements the five core technologies of Player-informed Interactive Storytelling.

# Chapter 5

# Empirical Evaluation

To evaluate PaSSAGE's success in telling interactive stories that maximize enjoyment, agency, and replay value, I constructed a storyworld based on the classical fairy tale, "Little Red Riding Hood" by the Brothers Grimm [15], and successfully gathered over one hundred participants to come and play through the story. In the following sections, I describe the logistics of my user study, the design of my storyworld, the set of encounters that PaSSAGE had to choose from at each phase of the Hero's Journey, the three versions of the storyworld that I tested in the study, and the results that I obtained from my experiments.

## 5.1 The User Study

Conducted at the University of Alberta in the Department of Computing science, my user study took place in two stages. The first stage involved 98 undergraduate university students, aged 17 to 38 (mean: 20, median: 19). Due to technical difficulties and other issues that will be discussed later on (Section 6.2), data from 86 of these participants was retained for analysis. The second stage was an extension to the first and involved 18 members of the general public, aged 18 to 32 (mean: 23, median: 22); data from 15 of these participants was retained. Both stages required at most an hour of each participant's time.

### 5.1.1 Sources of Participants

Having no prior knowledge on which to base my selection of participants, I used the Psychology 104/105 Research Participant Pool at the University of Alberta for the first stage of the study; in exchange for a portion of their course credit, students enrolled in Psychology 104 and 105 participate in user studies associated with ongoing research in the department of Psychology; having Marcia Spetch as a co-investigator on the PaSSAGE project granted us access to this source of participants.

For the second stage of the study, I decided to focus on a particular group of participants - females with high prior experience playing video games; the reason for this choice of focus arose from information that I learned during the first stage, and is discussed in Section 5.7. I advertised

the study via posters, e-mails, and word of mouth, and attracted a variety of players. To compensate them for their time, each participant in the second stage received a $10 honourarium.

ARE YOU GAME?
To help evaluate an ongoing research project, we are inviting [redacted] to participate in a user study on storytelling in games.
If you're a female who typically plays video games for two or more hours each week, please consider participating in this study.
The study will take place in a computer lab in the Computing Science Centre, lasting 30-50 minutes. To compensate for this time, participants will receive a small honourarium.
For more information, send an e-mail to storytesting@gmail.com

Figure 5.1: The poster that I created to attract participants for the second stage of the study.

The materials that I used to solicit the participants for both stages of the study can be found in Appendix A, along with the ethics application that was approved by the Research and Ethics Board of the University of Alberta as part of arranging for my study.

**Participant Influences on Game Design**

Given the restrictions of the Psychology 104/105 Research Participant Pool on the total duration of each student's participation, it was necessary for every participant to finish playing the game within 40 minutes. To help ensure that this would take place, and to encourage players to focus on evaluating the story they were experiencing rather than the mechanics of the *Neverwinter Nights* (NWN) engine, I made several adjustments to the design of the game that was presented.

One major adjustment was made to the user interface of the NWN game engine; Figure 5.2 shows the traditional graphical user interface of the NWN engine. In the centre area of the screen, players can (left-) click on the ground to move about the world, on characters to converse or attack, or on objects to collect or activate them. They can also drag the mouse to rotate the camera, and right click on objects to choose context-sensitive action commands. At the bottom of the screen, the player can type to enter text which their character will then "speak" (shown in the box at the bottom left); there is also a list of skills, magic spells, and items that the player might choose to use. In the top left corner of the screen, the player can converse with non-player characters by selecting from sets of pre-authored responses to the comments that the NPCs make. In the top right corner of the screen, the player's portrait and health bar are shown, along with several buttons for accessing

Figure 5.2: The standard user interface to *Neverwinter Nights*.

her inventory (a collection game items), her journal, a sheet showing her vital statistics, and more. Anticipating that players unfamiliar with NWN could potentially invest a significant amount of time in investigating all of these features, I elected to present a simpler interface. Figure 5.3 shows the result of this simplification; the only modes of interaction that remain are those supported by (left-) clicking: movement, conversation, attacking, and collecting or activating objects[1]. I used this simplified interface across all of my experiments.

In designing the areas for the study's storyworld, I deviated from the traditional tendency of NWN-based adventures to include large amounts of miscellaneous objects in the world for the player to collect and interact with (*e.g.* treasure chests, crates, gems, or potions). Such objects, while potentially appealing for Power Gamers to collect, rarely have any purpose in terms of storytelling. Expecting that players could spend a significant amount of time exploring and collecting objects without experiencing any of PaSSAGE's story content, I limited the objects in the storyworld to those that served some purpose in PaSSAGE's encounters.

### 5.1.2 Experimental Setup

I designed and ran my experiments as follows. Upon entering the testing room, each participant was assigned a seat at a computer workstation, and each workstation had one of three versions of the study's storyworld ready to play. The details of these three versions are described in Section 5.4; in brief, one version had a static (non-adaptive), linear story designed to closely follow the plot of the "Little Red Riding Hood" fairy tale, another had a static, branching story designed to ensure coverage of PaSSAGE's set of encounters, and the third had a story which was adapted by PaSSAGE

[1] I achieved this simplification using NWN's "cut-scene mode", which hides all of the interface aside from the game world and conversation boxes, and can be configured to allow the player to use the left mouse button as normal.

Figure 5.3: My simplified user interface to *Neverwinter Nights*.

online, based on its learned player model. A text-based log was generated for each player's experience, recording the list of encounters that occurred and the changes that were made to the player model. I additionally captured a video of each player's experience using Fraps, a software-based screen video capture tool [22].

Before playing, each participant received both verbal and written introductions to the study, as well as a sheet of instructions explaining how to use my simplified NWN interface (Section 5.1.1). To avoid novelty-related bias, all of the participants were told that they would be asked to first play one of several video game stories created by students at the University of Alberta, and then rate the story along several metrics, such as their sense of fun, influence over the story (agency), *etc.*. To the best of my knowledge, the participants did not know that an adaptive interactive storytelling system (PaSSAGE) was being tested alongside two hand-crafted stories.

Each participant was given roughly five minutes to become accustomed to the interface via an introductory sequence created in the Aurora Toolset, and then they began to play (for an example of what might occur during gameplay, see Section 5.5). After playing, each player was asked to fill out a survey to rate their experience along several bi-polar values and offer any comments that they may have had (see Section 5.1.3 for a discussion of the rated values). Participants were also asked to indicate their age and gender. Following the completion of the survey, each participant received a written debriefing explaining the true nature of the study as well as the reason why they were initially deceived (concerning the nature of the stories that they experienced).

My goal was to compare PaSSAGE's stories to my two hand-crafted stories; as a result, roughly half of the participants (50/101) played through stories generated by PaSSAGE, while 28 experienced the static, linear story, and the remaining 22 experienced the static, branching story[2].

[2]The numbers for the two static stories differ due to the data from several participants having been discarded (Section 6.2).

| | | | | | | |
|---|---|---|---|---|---|---|
| **In comparison to an average video game of similar length, that you've played in the past (or your expectation of one), how enjoyable was your game experience?** | | | | | | |
| Less Fun | 1 | 2 | 3 | 4 | 5 | More Fun |
| **I felt as though my actions were influencing the story** | | | | | | |
| Never | 1 | 2 | 3 | 4 | 5 | Always |
| **Overall, my interest in playing this game again is** | | | | | | |
| Low | 1 | 2 | 3 | 4 | 5 | High |
| **In an average week, the amount of time I spend playing video games is:** | | | | | | |
| None at all | 1 | 2 | 3 | 4 | 5 | Greater than 10 hours |
| **My experience playing this game was** | | | | | | |
| Interesting | 1 | 2 | 3 | 4 | 5 | Boring |
| Plausible | 1 | 2 | 3 | 4 | 5 | Implausible |
| Engaging | 1 | 2 | 3 | 4 | 5 | Shallow |
| Predictable | 1 | 2 | 3 | 4 | 5 | Surprising |
| Fascinating | 1 | 2 | 3 | 4 | 5 | Ordinary |
| Repetitive | 1 | 2 | 3 | 4 | 5 | Varied |
| Difficult to follow | 1 | 2 | 3 | 4 | 5 | Easy to follow |
| Creative | 1 | 2 | 3 | 4 | 5 | Conventional |

Figure 5.4: Metrics for player ratings in the user study survey.

### 5.1.3 Post-game Survey

Figure 5.4 shows the set of ratings that players were asked to provide after playing through the story that they were given. The structure and questions of the survey are adapted from similar questionnaires that are used by the ScriptEase research group at the University of Alberta, as they had previously conducted user studies to compare video game stories [1]. The first three ratings ask the player to directly judge their story in terms of the three primary goals of enjoyment, agency, and replay value. The fourth rating aims to identify the player's prior experience playing video games. The remainder of the ratings ask for the player's evaluation of the story across several other metrics. Although they were not the focus of this study, the scales for Engaging/Shallow and Plausible/Implausible correspond well with two of the three desirable properties of good interactive

stories; namely, immersion and plot consistency, respectively. The remaining story property, global structure, can be thought of as a combination of the other scales. Players were asked to circle one of the numbers along each scale; when players circled one of the scale labels instead, their rating was interpreted to mean the nearest number on the scale (*e.g.* circling the label 'Interesting' would have been interpreted as a value of 1 on the Interesting/Boring scale, while circling 'Boring' would have been interpreted as a value of 5). The order in which the labels appear is deliberately inconsistent, in that some desirable qualities appear on the left, while others appear on the right. The goal of using this arrangement was to discourage players from simply deciding to mark a particular value (*e.g.* 4 out of 5) for every rating.

## 5.2 The Storyworld

Implementing the study's storyworld using BioWare Corp.'s Aurora Neverwinter Toolset, a software tool for designing and implementing complete, story-based, interactive experiences [7], allowed me to speed my development and conserve resources. As I mentioned above, I elected to base the storyworld on the classical fairy tale "Little Red Riding Hood"; I made this choice for two reasons: to allow the easy implementation of a well-regarded, static, linear story to compare against, and because Interactive Storytelling implementations of "Little Red Riding Hood" were recently the focus of a workshop on "The Authoring Process in Interactive Storytelling" at TIDSE'06 [40]. To avoid any familiarity bias in players' ratings of the static, linear story, I replaced the actor and place names that appear in the Red Riding Hood story with names of my own devising. To allow PaSSAGE to convey its stories to its players, I created a setting including several areas and actors.

### 5.2.1 The Areas

Like the story of Red Riding Hood, I set the study's storyworld in the vicinity of a small village at the edge of a forest. The story begins with the player at home, proceeds to the village outside, then into the nearby forest, and concludes at the house of one of the story's characters (Figure 5.5).

### 5.2.2 The Actors

I created a small set of actors for the study's storyworld, to be used both by PaSSAGE in adaptively telling its stories, and by the two static stories. Knowing in advance that participants in the study would only have enough time to play through one story, PaSSAGE's role-passing techniques (which currently contribute only to improving replay value) were active, but only ever had one actor to choose from (*e.g.* the Troll was the only actor satisfying the condition of being a potential threshold guardian). The following sections describe each actor and their role within the storyworld.

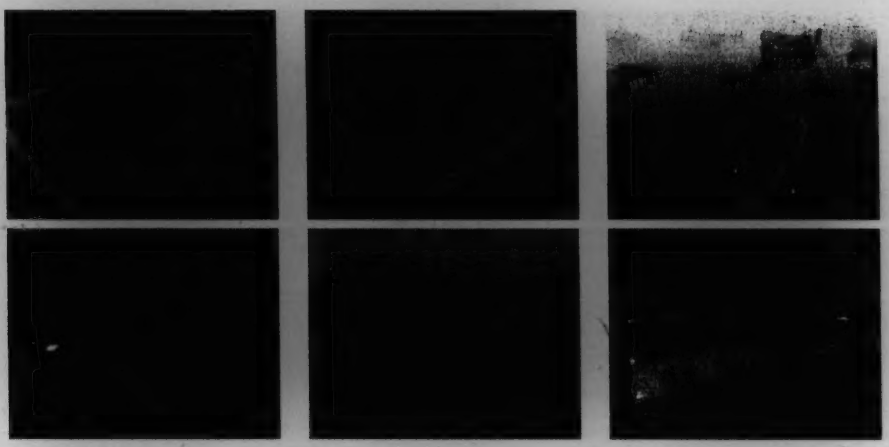

Figure 5.5: The areas in my evaluation storyworld. Top row, from left to right: Downstairs in the player character's home; Upstairs in the player character's home; Eldon's Watch, the player's home village. Bottom row, from left to right: Maedorn Forest; Forest Clearing; Forest House.

**Annara Tel'mane - The Player**

Annara is the player's character, intended to represent Red Riding Hood from the fairy tale story. She is a young woman who lives at home with her father, and often goes adventuring in the forest with her close friend, Arnell Sampson.

**Father - The Starter**

Father is, as one might suspect, Annara's father. He is the first actor that Annara meets, providing a lesson in the history of the surrounding kingdom, Erafor, before Annara may venture into the village outside (Section 5.3.1 explains the purpose of this lesson).

**Arnell Sampson - The Caller**

Arnell is a good friend of Annara's, and appears early in the story to deliver the *Call to Adventure* of the Hero's Journey, in place of Red's mother sending her off to visit her grandmother. Unfortunately, Arnell's mother has refused to let him join Annara on her journey.

**The Troll - The Villain**

The Troll is the villain of the story, intended to represent the Wolf that troubles Red Riding Hood in her adventure. The troll serves both as the guardian of the threshold (for the phase *Crossing the Threshold* of the Hero's Journey), and as the source of the final *Ordeal* that ends the story.

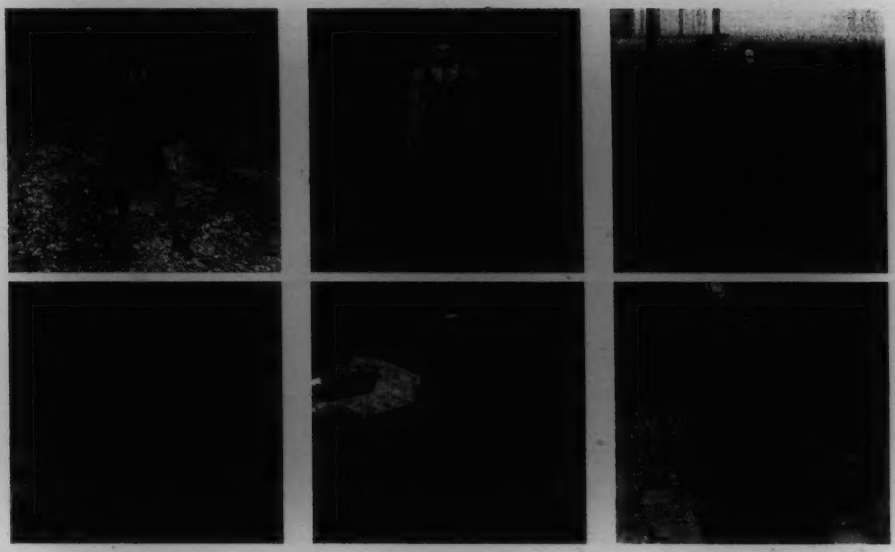

Figure 5.6: The actors in my evaluation storyworld. Top row, from left to right: Annara Tel'mane, Father, Arnell Sampson. Bottom row, from left to right: The Troll, Jarnas Galennald, Vero Willian.

**Jarnas Galennald - The Victim**

Jarnas, a potion-maker who lives in Maedorn Forest, is the first victim of the Troll's villainy, just as Red's grandmother is the first to be eaten by the wolf.

**Vero Willian - The Wizard**

Vero is a good wizard who patrols the forest paths, and is intended to represent the Woodsman that ultimately rescues Red and her Grandmother from the belly of the Wolf. Annara may additionally meet Vero on her way to visit Jarnas, as part of the *Road of Trials* phase of the Hero's Journey.

## 5.3 The Encounters

To allow PaSSAGE to learn a player model and use it to adaptively construct its stories, I created a set of nine potential encounters[3] and divided them into five phases of the Hero's Journey: *Home*, the *Call to Adventure*, *Crossing the Threshold*, the *Trials*, and the *Ordeal*. Table 5.1 shows the play-style annotations that I added to every branch in each encounter that PaSSAGE had the opportunity to choose while telling its stories. The encounters for the *Home* and *Ordeal* phases of the Hero's Journey were not chosen by PaSSAGE; the Home encounter occurred for all players, and one of the Eaten & Rescued and Wizard vs. Villain encounters occurred based on whether PaSSAGE had previously selected the Distraction encounter or the Recruitment encounter, respectively (this decision was made to ensure a consistent ending to the story). Due to time limitations in preparing

[3] My previous publication incorrectly lists this number as eight [50].

| Encounter | Branch | Play-style Annotations | | | | |
|---|---|---|---|---|---|---|
| | | Fighter | Method Actor | Storyteller | Tactician | Power Gamer |
| Home | - | - | - | - | - | - |
| Mission of Mercy | Default | ✓✓ | - | ✓✓✓✓✓ | - | - |
| Collect Bounties | Default | - | - | - | ✓✓ | ✓✓✓✓✓ |
| Distraction | Ingredient | ✓✓ | - | - | ✓✓✓✓✓ | ✓✓✓✓✓ |
| | Fight | ✓✓✓✓✓ | - | ✓✓ | - | - |
| Recruitment | Default | ✓✓✓✓✓ | ✓✓✓✓✓ | ✓✓ | - | ✓✓✓✓✓ |
| Traveller in Need | Default | - | - | ✓✓✓✓✓ | ✓✓✓✓✓ | ✓✓ |
| Monster Attack | Default | ✓✓✓✓✓ | - | - | ✓✓ | ✓✓✓✓✓ |
| Eaten & Rescued | - | - | - | - | - | - | - |
| Wizard vs. Villain | - | - | - | - | - | - | - |

Table 5.1: Play-style annotations for each of the encounters that could chosen by PaSSAGE. Double lines separate phases of the Hero's Journey.

for the study, I did not create as many branches for the encounters as I had originally hoped for, and so lack variety for players who have a preference toward the Method Actor type. To promote model learning even in the absence of branches, NPC conversations within the encounters were designed to provide the player with opportunities to express her play style (by choosing lines of text to say), and player-model adjustments were attached to all such statements (*e.g.* choosing "**Sigh*... here we go again...*" in response to an NPC suggesting going to collect bounties causes PaSSAGE to decrease the player's Power Gamer inclination in the model). The following sections describe storyworld's encounters in more detail, organized by the phase of the Hero's Journey in which they might occur.

### 5.3.1 Home

In the Hero's Journey, the hero begins at home. In the storyworld, Annara wakes up in her room after a late night out, and is greeted by her Father, who presents her with a history lesson. During the lesson, the player is asked to comment several times on a story about Prince Vi'dal, a man who was once the prince of the surrounding kingdom. Through the player's comments, PaSSAGE quickly learns a model of her preferred style of play, gaining sufficient knowledge to make its first choice in the story - which *Call to Adventure* should occur?

### 5.3.2 The Call to Adventure

The *Call to Adventure* is the event that motivates the hero to embark on his journey. In the storyworld, Arnell arrives to deliver the call as soon as the player leaves her house. For this phase, two encounters are available, each having only one branch; one involves a mission of mercy in the forest concerning a friend of Jarnas' who has been turned into a monster (Mission of Mercy in Table 5.1), and the other involves collecting lucrative bounties by finding a rare mushroom in the forest (Collect Bounties in Table 5.1).

### 5.3.3 Crossing the Threshold

At some point in his journey, the hero must cross a threshold before continuing onward. In the storyworld, this threshold is a bridge over a canyon that lies along the player's path through Madeorn Forest. The bridge is guarded by the Troll, who PaSSAGE uses to present one of two encounters to the player; one involves the Troll distracting the player by sending her off the path in search of a rare mushroom (this is analogous to the Wolf sending Red Riding Hood to pick flowers - Distraction in Table 5.1), and the other involves the Troll attempting to recruit the player into a nefarious plan to capture the Wizard, who has been hunting the Troll relentlessly (Recruitment in Table 5.1).

**Distraction Branch: Fighter**

To appeal to Fighters, I included a branch in the Distraction encounter for the player to fight the Troll instead of searching for the mushroom. If PaSSAGE selects this branch, the player's conversation with the troll is restructured as follows, to encourage the player to fight (see *Hinting* in Section 4.5.3). When the player asks if she can cross the forest bridge, instead of responding neutrally ("*Oh ho! All in good time, all in good time, young woman.*"), the Troll attempts to goad the player into a fight, saying "*And what happensss if I refuse, tiny girl?*". The player's responses are also re-ordered to encourage a more aggressive response, as shown in Figure 5.7.

Figure 5.7: Differences in Troll dialogue used to hint both branches of the Distraction encounter. Left: Neutral Branch. Right: Fighter Branch.

### 5.3.4 The Trials

The *Trials* represent a set of challenges that the hero must overcome early on in her journey. Though not included in the traditional Little Red Riding Hood story, I added this phase from the Hero's Journey to provide PaSSAGE with an additional opportunity to adapt the story. In one of the two possible encounters, a traveller along the forest path approaches the player and asks for her help in solving a riddle (Traveller in Need in Table 5.1). In the other encounter, the player is suddenly attacked by monsters as she walks through the forest (Monster Attack in Table 5.1).

### 5.3.5 The Ordeal

The *Ordeal* is a confrontation between the hero and the primary forces that are set against her. In the storyworld, two types of ordeal were possible; as stated above, the ordeal that each player experienced was determined by PaSSAGE's selection between the Distraction and Recruitment encounters in the *Crossing the Threshold* phase, to ensure a consistent ending to the story.

**Distraction → Eaten & Rescued**

The Distraction encounter leads to an *Ordeal* encounter in which the player is captured and eaten by the Troll, and subsequently rescued by the Wizard (this is analogous to the Woodsman rescuing Red and her Grandma from the Wolf - Eaten & Rescued in Table 5.1). The story ends with the Wizard thanking the player for helping him to find the Troll and making the forest safe again.

**Recruitment → Wizard vs. Villain**

The Recruitment encounter leads to an *Ordeal* encounter which can ultimately result in one of four endings to the story. The encounter involves a plot designed by the Troll to disguise himself as Jarnas and capture the Wizard; the ending that occurs is based on the choices that the player makes during the encounter. When the Troll asks the player to lure the Wizard inside Jarnas' house, the player may choose to either cooperate and send the Wizard inside unaware, inform the Wizard of the Troll's plan, or send the Wizard on his way. If the player tells the Wizard that the Troll is inside, the story will end with the Wizard destroying the Troll, and thanking the player for her help (Ending #1). If the player sends the Wizard on his way, the Troll will attack the player out of anger, and the Wizard will return to rescue her (Ending #2). If the player sends the Wizard inside unaware, the Troll will eat the Wizard and thank the player for her help. At this point, the player is given the opportunity to reconsider her deal with the Troll; she can accept the reward of untold riches (Ending #3), or destroy the Troll and rescue both Jarnas and the Wizard (Ending #4).

## 5.4 The Three Compared Versions

As mentioned in Section 5.1.2, I performed my evaluation of PaSSAGE's storytelling abilities by comparing three versions of the study's storyworld. One version contained a static, linear story, designed to closely resemble the Little Red Riding Hood fairly tale, using the encounter sequence: Home, Mission of Mercy, Distraction, Traveller in Need, and Eaten & Rescued. Although it was possible for players to fight the Troll in the Distraction encounter of the linear story, no Hinting toward this branch was performed. The second version contained a static, branching story, designed to include the encounters that were missed by the linear story; it used the sequence: Home, Collect Bounties, Recruitment, Monster Attack, and Wizard vs. Villain (the branching occurs within the final encounter, yielding one of four endings - see Section 5.3.5). In the third version of the storyworld, PaSSAGE chose from the available encounters in each of the *Call to Adventure*, *Crossing*

*the Threshold*, and *Road of Trials* phases of the Hero's Journey, based on its learned model of the player's preferred style of play. Figure 5.8 shows the story space that connects the encounters in the storyworld. The dashed line shows the linear story, while the thick solid line shows the branching story. The stories told by PaSSAGE could follow any line from the Home encounter to one of the five endings, with PaSSAGE choosing between encounters at decision nodes $D_1$, $D_2$, and $D_3$.

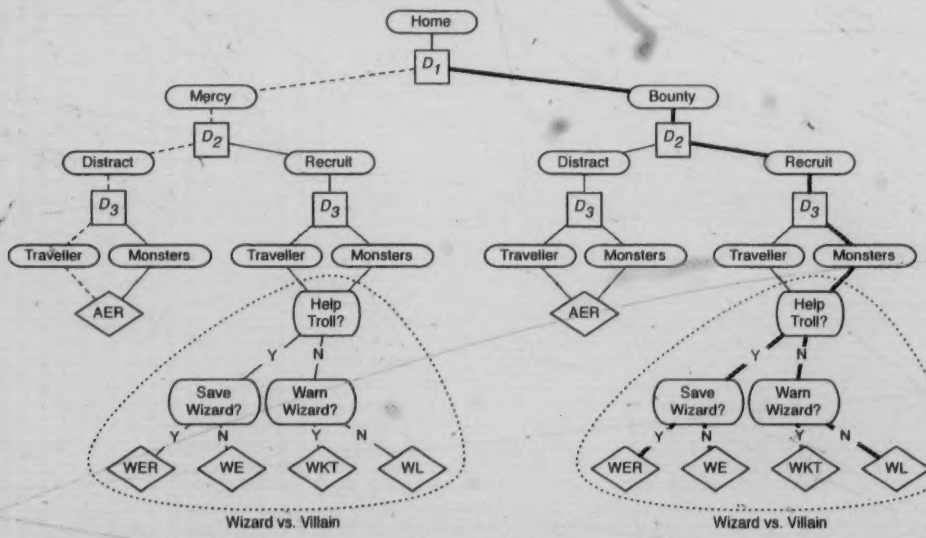


Figure 5.8: The story space of my evaluation storyworld. Rounded nodes are in-game events, diamonds are endings labelled by acronyms: AER = Annara (the player's character) Eaten & Rescued, WE = Wizard Eaten, WER = Wizard Eaten & Rescued, WKT = Wizard Kills Troll, and WL = Wizard Leaves. Square nodes ($D_{\#}$) show decisions made by PaSSAGE (figure adapted from [50]).

## 5.5 Adaptive Gameplay Walkthrough

The following is a walkthrough of one of the stories that was generated by PaSSAGE during the study; this walkthrough originally appeared in a previous publication, and has been updated to reference the content of this work [50]. In the walkthrough, I demonstrate both how the model was updated and how it was used in the decision nodes shown in Figure 5.8. An annotated video of this walkthrough can be found at the following URL: http://ircl.cs.ualberta.ca/games/passage/videos/

The player finds herself in her room in the basement of her house (Phase: *Home*, Encounter: Home); the player model begins at initial values (Fighter=1 Method Actor=1 Storyteller=1 Tactician=1 Power Gamer=1). The player's father arrives and presents a history lesson, during which she has the opportunity to comment several times on the events being related by selecting one of several pre-authored responses from a list (*e.g.* "*He should have helped the old man - there might have been a big reward!*"). With each comment, the player model is updated. In this case, the player's choice of comments indicate that her play style is a combination of a strong Method Actor and Power Gamer,

and somewhat of a Storyteller. Several model updates occur based the player's choices, resulting in the following model being created by the end of the lesson: (F=1 M=141 S=41 T=1 P=101). Once the lesson ends, the player is free to wander through the village outside.

As the player exits the house, PaSSAGE's Encounter Selection routine is activated (Phase: *Call to Adventure*), and an encounter must be selected ($D_1$). Two encounters are available, both involving the player character's good friend, Arnell. Given the player's demonstrated inclination toward being a Power Gamer (P=101), PaSSAGE selects an encounter in which Arnell describes a recently-posted set of bounties available for collection (Encounter: Collect Bounties in Table 5.1, Bounty in Figure 5.8) - ingredients for the potion-maker, Jarnas, who lives in the forest. When the player expresses disinterest in collecting the bounties, the model's Power Gamer value is decreased (F=1 M=141 S=41 T=1 P=61). Although it may have been beneficial at this point to switch to a different *Call to Adventure* encounter, implementing this feature remains as future work; PaSSAGE instead uses a backup motivation that was associated with the encounter (Section 4.5.3). In this case, Arnell relates the mysterious and rare nature of one of the desired ingredients.

When the player enters a nearby forest in search of the potion ingredients, PaSSAGE's Encounter Selection routine is activated again (Phase: *Crossing the Threshold*, $D_2$). Again, two encounters are available, but given the player's inclination toward being a Method Actor (M=141) and somewhat of a Power Gamer (P=61), an encounter is chosen wherein the Troll blocks the player's path, offering riches beyond imagination for helping to trap an evil Wizard in the forest (Encounter: Recruitment in Table 5.1, Recruit in Figure 5.8). The player agrees to go along with the dubious plot, and her modelled inclination toward the Method Actor and Storyteller types increase (F=1 M=181 S=81 T=1 P=61). The player continues through the forest while the Troll hurries to prepare the trap.

Along the player's way to Jarnas' house, PaSSAGE's Encounter Selection routine is activated for a third time (Phase: *Trials*, $D_3$) to choose an encounter to occur along the forest path. Given the player's new inclination toward storytelling, the encounter chosen involves the Wizard, who seems suspiciously similar to a character that was prominent in the history lesson earlier in the day (Encounter: Traveller in Need in Table 5.1, Traveller in Figure 5.8). The Wizard asks the player a riddle, which she agrees to solve. The final scene begins with the Wizard arriving outside of Jarnas' house with the Troll waiting inside (Encounter: Wizard vs. Villain). Instead of luring the Wizard into the Troll's trap, the player warns him of the Troll's presence, and a battle between the Troll and Wizard ensues (Help Troll?: N, Warn Wizard?: Y in Figure 5.8). The Wizard slays the Troll, and the land is safe once again (WKT in Figure 5.8).

## 5.6 Hypotheses

Toward my goal of having PaSSAGE achieve the primary goals of storytelling, I formulated the following three primary hypotheses:

**Hypothesis 1: Better Enjoyment.** PaSSAGE's adaptive stories will be rated as being more enjoyable than the two static stories.

**Hypothesis 2: Better Agency.** PaSSAGE's adaptive stories will give players a higher sense of agency than the two static stories.

**Hypothesis 3: Better Replay Value.** Players will be more interested in replaying PaSSAGE's stories than the two static stories.

In addition to the three primary hypotheses, I also investigated PaSSAGE's performance vs. the two static stories with respect to the other metrics that were included in the study's survey (*e.g.* forming the hypothesis that PaSSAGE's stories will be more engaging than the two fixed stories).

## 5.7 Results

I tested my hypotheses by averaging together corresponding ratings for the two static stories and comparing the results to the ratings that I collected for PaSSAGE's adaptive stories. My reason for combining together the ratings of the two static stories is as follows. Given that PaSSAGE requires multiple story alternatives to function, comparing any single static story directly to PaSSAGE could create an unfair bias concerning the quality of PaSSAGE's stories; if the encounters which were not used by the static story had been exceptionally well-made, PaSSAGE would have the unfair advantage in being able to use them. If the unused encounters were especially poor, then PaSSAGE would be at an unfair disadvantage. Crafting two stories which together include all of PaSSAGE's potential encounters and averaging their ratings together was my attempt to mitigate this problem.

In addition to comparing the story ratings as averages over the complete set of study participants', I identified three qualities of the participants as being potentially helpful in understanding which segment of a commercial market might best be targeted by PaSSAGE's adaptive stories. These qualities are based on each player's gender, prior video gaming experience, and the degree to which they were (or were not) confused by the story or gameplay (corresponding to the Easy to Follow survey metric). For each quality, I considered two sets (Male/Female, Low Experience (rated $\leq 2$ on the survey) / Experienced ($\geq 2$) and Easy to Follow ($\geq 4$) / Difficult to Follow ($\leq 3$). In all combinations tested, subsets restricted to those who found the game difficult to follow showed worse results than subsets that considered only players who found the game easy to follow; I will hence omit the Difficult to Follow set from the results that I present.

### 5.7.1 Stage 1: University Students

As I mentioned above, I ran the study in two stages, the first of which comprised exclusively students from a university Psychology class. Table 5.2 shows a summary of my findings for this stage of the study, considering the eighteen possible combinations of the five remaining quality values: Male, Female, Low Experience, Experienced, and Easy to Follow. Each row in the table represents a

| Row | Player Qualities | | | # Players | | % Confidence in Adaptive > Static | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **M/F** | **ETF** ($\geq 4$) | **Low/Exp** ($\leq 2$ / $\geq 2$) | $N_A$ | $N_S$ | **Fun** | **Agency** | **Replay Value** | **Interesting** | **Engaging** |
| 1 | * | * | * | 43 | 43 | 67 | 68 | 39 | 37 | 61 |
| 2 | M | * | * | 11 | 6 | 43 | 30 | 35 | 76 | 74 |
| 3 | F | * | * | 31 | 36 | 80 | 84 | 55 | 33 | 53 |
| 4 | * | ETF | * | 35 | 37 | 82 | 71 | 52 | 51 | 72 |
| 5 | * | * | Low | 32 | 32 | 85 | **91** | 69 | 59 | 50 |
| 6 | * | * | Exp | 19 | 16 | 62 | 55 | 26 | 35 | 79 |
| 7 | M | ETF | * | 10 | 5 | 57 | 33 | 50 | 72 | 70 |
| 8 | M | * | Low | 4 | 3 | 59 | 71 | 46 | 85 | 86 |
| 9 | M | * | Exp | 11 | 4 | 74 | 42 | 69 | 72 | 67 |
| 10 | F | ETF | * | 24 | 31 | 91 | 87 | 68 | 49 | 66 |
| 11 | F | * | Low | 28 | 29 | 83 | 89 | 71 | 48 | 35 |
| 12 | F | * | Exp | 7 | 11 | 76 | 80 | 40 | 29 | 71 |
| 13 | * | ETF | Low | 24 | 27 | **94** | **91** | **82** | 70 | 55 |
| 14 | * | ETF | Exp | 17 | 15 | 76 | 60 | 36 | 39 | **96** |
| 15 | M | ETF | Low ($\leq 3$) | 4 | 2 | 82 | 74 | 68 | **93** | 91 |
| 16 | M | ETF | Exp | 10 | 4 | 73 | 39 | 68 | 76 | 76 |
| 17 | F | ETF | Low | 21 | 25 | 91 | 89 | **81** | 65 | 38 |
| 18 | F | ETF | Exp | 6 | 10 | 91 | 84 | 55 | 27 | 93 |

Table 5.2: Confidence levels in support of my hypotheses for eighteen data subsets, for the first stage of the study. M = Male, F = Female, ETF = Easy To Follow, Low = Low Experience, and Exp = Experienced. These symbols describe restrictions on the qualities of the participants in each subset considered. Asterisks indicate unrestricted qualities. $N_A$ and $N_S$ represent the numbers of participants in the subset who played the Adaptive and Static stories, respectively.

different subset of players, where members of each subset are restricted by the values listed in the columns titled "Player Qualities" (an asterisk indicates no restriction). For example, row 5 considers the subset of all players who had low prior experience playing video games, while row 10 considers female players who rated the game as being easy to follow, with no restriction on prior experience. For each subset, the number of players in that subset who played the adaptive and static stories are given by the columns titled $N_A$ and $N_S$, respectively. The remaining five columns give confidence values in support of my three primary hypotheses, as well as two secondary hypotheses that I selected to show particularly encouraging results. All confidence values were calculated using a one tailed t-test of the null hypothesis ($Metric_{Adaptive} \leq Metric_{Static}$), where *Metric* was the average ratings for enjoyment, agency, replay value, *etc.*. The confidence percentages in Table 5.2 show how confident one can be in rejecting the null hypothesis and claiming that ($Metric_{Adaptive} > Metric_{Static}$) is true in general. While the confidence values for all players offer little support (row 1), some of the subsets that I considered show more promise. The most encouraging results from this stage of the study follow; for detailed results, see Appendix B.

**Result 1:** For female players who found the game easy to follow, PaSSAGE's stories were more fun than the two static stories with 91% confidence and provided a better sense of agency with 87%

confidence (row 10 in Table 5.3). A result for this subset was reported in my previous publication, but included four invalid data points that were discovered after printing [50].

**Result 2:** For players with low prior experience playing video games who found the game easy to follow, PaSSAGE's adaptive stories were more enjoyable (more fun) than the two static stories with 94% confidence, provided a better sense of agency with 91% confidence, and had better replay value with 82% confidence (row 13 in Table 5.2).

**Result 3:** For players who had prior experience playing video games and found the game easy to follow, PaSSAGE's stories were more engaging than the two static stories with 96% confidence (row 14 in Table 5.2).

**Result 4:** For male players with mid-to-low prior gaming experience (rated $\leq 3$ on the survey), PaSSAGE's stories were more interesting than the two static stories with 93% confidence (row 15 in Table 5.2).

**Result 5:** For female players who had prior experience playing video games and found the game easy to follow, PaSSAGE's stories were more fun than the two static stories with 91% confidence, provided a better sense of agency with 84% confidence, and were more engaging with 93% confidence (row 18 in Table 5.2).

### 5.7.2 Stage 2: Female Gamers

After seeing the results of the first stage of the study, I noticed that in addition to the confidence values reported in Result 5, the confidence values for Plausibility and Creativity were also encouraging (both were 79% - see Table B.16), and could potentially benefit from additional data. To obtain this data, I focused the second stage of the study on female players who had prior experience playing video games. Fifteen such players participated in the study, and aside from the following differences, the experimental conditions were identical to the first study. The differences in experimental conditions were: 1) the physical equipment used to run the game, 2) the absence of other participants in the lab (participants were processed in parallel in Stage 1), and 3) the lack of minor errors in the study's storyworld that invalidated some results in Stage 1 (see Section 6.2). Table 5.3 shows a summary of the results of extending the data from Stage 1 with the ratings obtained from the participants in Stage 2; the format of the table is the same as that of Table 5.2. Unfortunately, the results for female gamers (row 18, Table C.12) were not as I had hoped, with the confidence levels decreasing for all metrics except for Plausibility, which increased to 82%. Given that no new Male players were added in Stage 2, the results for all subsets that were restricted to Male players still hold. The most encouraging results from this stage follow; for detailed results, see Appendix C.

**Result 6:** Considering all players, PaSSAGE's stories were more fun than the two static stories with 73% confidence and provided a better sense of agency with 74% confidence (row 1 in Table 5.3).

Although these values are certainly too low to claim statistical significance, they are both six percent higher than they were in Stage 1.

**Result 7:** For female players who found the game easy to follow, PaSSAGE's stories were more fun than the two static stories with 91% confidence and provided a better sense of agency with 86% confidence (row 10 in Table 5.3). The value for agency decreased slightly from Stage 1.

**Result 8:** For players with low prior experience playing video games who found the game easy to follow, PaSSAGE's adaptive stories were more enjoyable (more fun) than the two static stories with 91% confidence, provided a better sense of agency with 87% confidence, and had better replay value with 72% confidence (row 13 in Table 5.3). These values decreased from Stage 1.

**Result 9:** For players who had prior experience playing video games and found the game easy to follow, PaSSAGE's stories were more engaging than the two static stories with 87% confidence (row 14 in Table 5.2). This value decreased from Stage 1.

| Row | Player Qualities | | | # Players | | % Confidence in Adaptive > Static | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **M/F** | **ETF** ($\geq 4$) | **Low/Exp** ($\leq 2$ / $\geq 2$) | $N_A$ | $N_S$ | **Fun** | **Agency** | **Replay Value** | **Interesting** | **Engaging** |
| 1 | * | * | * | 50 | 51 | 73 | 74 | 37 | 27 | 58 |
| 2 | M | * | * | 11 | 6 | 43 | 30 | 35 | 76 | 74 |
| 3 | F | * | * | 38 | 44 | 83 | 85 | 49 | 22 | 50 |
| 4 | * | ETF | * | 41 | 45 | 85 | 75 | 45 | 32 | 62 |
| 5 | * | * | Low | 36 | 35 | 80 | **88** | 64 | 42 | 47 |
| 6 | * | * | Exp | 24 | 21 | 73 | 62 | 15 | 24 | 65 |
| 7 | M | ETF | * | 10 | 5 | 57 | 33 | 50 | 72 | 70 |
| 8 | M | * | Low | 4 | 3 | 59 | 71 | 46 | 85 | 86 |
| 9 | M | * | Exp | 11 | 4 | 74 | 42 | 69 | 72 | 67 |
| 10 | F | ETF | * | 30 | 39 | **91** | 86 | 56 | 28 | 53 |
| 11 | F | * | Low | 32 | 32 | 78 | 85 | 65 | 32 | 33 |
| 12 | F | * | Exp | 12 | 16 | 77 | 71 | 17 | 14 | 48 |
| 13 | * | ETF | Low | 27 | 30 | **91** | **87** | **72** | 51 | 44 |
| 14 | * | ETF | Exp | 22 | 20 | 83 | 65 | 22 | 27 | 87 |
| 15 | M | ETF | Low ($\leq 3$) | 4 | 2 | 82 | 74 | 68 | **93** | **91** |
| 16 | M | ETF | Exp | 10 | 4 | 73 | 39 | 68 | 76 | 76 |
| 17 | F | ETF | Low | 24 | 28 | 86 | 84 | 70 | 39 | 28 |
| 18 | F | ETF | Exp | 11 | 15 | 88 | 75 | 24 | 13 | 72 |

Table 5.3: Confidence levels in support of my hypotheses for eighteen data subsets, for the second stage of the study. M = Male, F = Female, ETF = Easy To Follow, Low = Low Experience, and Exp = Experienced. These symbols describe restrictions on the qualities of the participants in each subset considered. Asterisks indicate unrestricted qualities. $N_A$ and $N_S$ represent the numbers of participants in the subset who played the Adaptive and Static stories, respectively.

## 5.8 Analysis

Over all 101 players who participated in the user study, my results concerning PaSSAGE's performance are inconclusive, having respectively obtained confidence levels of only 73%, 74%, and 37% for my hypotheses that PaSSAGE's adaptive stories' would provide better enjoyment, afford more agency, and be more tempting to replay in comparison to the static stories that I created. The best overall results were found by considering only players with low prior video gaming experience who found the game easy to follow (91%, 87%, 72%); why was this the case? Toward answering this question, I investigated the set of players falling outside of the low-prior-experience/easy-to-follow set, namely, all players who either had higher prior gaming experience ($\geq 3$) or players who found the game to be difficult to follow ($\leq 3$), thinking that perhaps such players may have provided especially extreme ratings, increasing the standard deviation across all of the ratings and decreasing the calculated confidence values as a result. Table 5.4 shows results toward investigating this possibility, reporting the means and standard deviations of the ratings for enjoyment for two subsets of the data: players with low prior gaming experience who found the game easy to follow (the most promising subset), and the disjunction of these sets; that is, the union of the subset of players who had high prior gaming experience with the subset of players who found the game hard to follow (this union is the set that I hypothesized about above). Curiously, my hypothesis of extreme player ratings seems to be supported by the players who played through the static stories (the means remain almost constant while the standard deviations show a sharp increase from the first subset to the second), but not by the players who played through the adaptive stories (where both the means and standard deviations drop from the first subset to the second).

| Rating: Fun | LE and ETF | HE or HTF |
|---|---|---|
| **Adaptive Mean** | $3.37 \pm 0.97$ | $2.91 \pm 0.90$ |
| **Static Mean** | $3.03 \pm 0.89$ | $3.05 \pm 1.02$ |

Table 5.4: Means and standard deviations for player ratings of enjoyment (fun) for two subsets: those with low prior gaming experience (LE) who found the game easy to follow (ETF), and the disjunction between the previous two sets of players (players with high prior experience (HE - ratings $\geq 3$) or players who found the game hard to follow (HTF - ratings $\leq 3$)).

### 5.8.1 Additional Hypotheses: Comparing Subsets of Players

Noting the relatively large difference between the mean ratings of enjoyment for the adaptive stories when considering the two participant subsets shown in Table 5.4, I formed a new set of hypotheses concerning the ratings offered by each subset; namely, that low experience players who found the game easy to follow rated PaSSAGE's adaptive stories more highly (*i.e.*, found them to be more fun, have better agency, *etc.*) than the group of players falling outside of this subset. Table 5.5 shows the results of a one-tailed, heteroscedastic[4] t-test, testing the null hypothe-

[4]Heteroscedastic refers to assuming unequal variances in the test populations.

sis ($MetricAdaptive_{LE\ and\ ETF} \leq MetricAdaptive_{HE\ or\ HTF}$), where *MetricAdaptive* denotes the average ratings that PaSSAGE's adaptive stories received for enjoyment, agency, replay value, *etc.*, and LE, ETF, HE, and HTF denote 'Low Experience', 'Easy To Follow', 'High Experience', and 'Hard To Follow', respectively. To aid in my subsequent discussion, I also present the same measurement made for the static stories of the study instead[5] (see Table 5.6). This new data is given in Table 5.5 and summarized by Result 10.

**Result 10:** Players with low prior experience playing video games who found the game easy to follow found that PaSSAGE's adaptive stories were: 1) more enjoyable than did all other players in the study with 95% confidence, 2) provided a better sense of agency with 95% confidence, 3) had better replay value with 96% confidence, 4) were more interesting with 87% confidence, 5) were more plausible with 93% confidence, and 6) were more varied with 86% confidence (Table 5.5).

| $N_{LEandETF}$: 27, $N_{HEorHTF}$: 23 | LE and ETF | HE or HTF | % Confidence |
|---|---|---|---|
| **Fun** | 3.3704 | 2.913 | 95 |
| **Agency** | 4 | 3.4348 | 95 |
| **Replay Value** | 3.3704 | 2.7826 | 96 |
| **Gaming Experience** | 1.2963 | 3.087 | - |
| **Interesting** | 3.7407 | 3.3913 | 87 |
| **Plausible** | 3.4815 | 3.1304 | 93 |
| **Engaging** | 3.5926 | 3.3913 | 73 |
| **Surprising** | 2.6667 | 2.9565 | 19 |
| **Fascinating** | 3.037 | 2.913 | 66 |
| **Varied** | 3.5185 | 3.1739 | 86 |
| **Easy to Follow** | 4.7407 | 3.913 | - |
| **Creative** | 3.2963 | 3 | 79 |

Table 5.5: Average ratings for only the adaptive stories, comparing two subsets of players: those who found the game easy to follow and had low prior gaming experience (LE and ETF), and all other players (those who found the game hard to follow or had high prior gaming experience (HE or HTF)). Confidence values show support for the hypotheses that the players in the first subset (LE and ETF) rated the adaptive stories higher than did the players in the second subset (HE or HTF).

## Summary

In this chapter, I presented the details of a two-stage human user study that I ran to evaluate PaSSAGE's ability to tell player-specific interactive stories. I described the sources of my participants and my experimental setup, which involved testing PaSSAGE's adaptive stories against two static stories, all of which were set in a storyworld designed to resemble the classic fairly tale "Little Red Riding Hood" [15]. I described this storyworld in detail, and provided an annotated walkthrough of one of the stories that PaSSAGE generated during the study. I presented the primary hypotheses of my experiment, which stated that PaSSAGE's adaptive stories would be rated more highly

[5] In Appendices B and C and Tables 5.5 and 5.6, confidence values are omitted for metrics whose values were used to select the subset of players being considered.

| $N_{LE,ETF}$: 30, $N_{HEorHTF}$: 21 | LE, ETF | HE or HTF | % Confidence |
|---|---|---|---|
| **Fun** | 3.0333 | 3.0476 | 47 |
| **Agency** | 3.6667 | 3.4762 | 71 |
| **Replay Value** | 3.1667 | 3.1905 | 47 |
| **Gaming Experience** | 1.1667 | 2.9524 | - |
| **Interesting** | 3.7333 | 3.6667 | 59 |
| **Plausible** | 3.3667 | 3.2857 | 63 |
| **Engaging** | 3.6333 | 3.1905 | 89 |
| **Surprising** | 2.8 | 2.8571 | 42 |
| **Fascinating** | 2.9 | 3.2857 | 10 |
| **Varied** | 3.5 | 3.4286 | 57 |
| **Easy to Follow** | 4.6667 | 4.1429 | - |
| **Creative** | 3.3 | 3.2857 | 51 |

Table 5.6: Average ratings for only the static stories, comparing two subsets of players: those who found the game easy to follow and had low prior gaming experience (LE, ETF), and all other players (those who found the game hard to follow or had high prior gaming experience (HE,HTF)). Confidence values show support for the hypotheses that the players in the first subset (LE,ETF) rated the static stories higher than did the players in the second subset (HE,HTF).

than the two static stories over a variety of measures, where ratings were collected from players via post-game surveys. I presented summaries of my results from both stages of the study (details are in Appendices B and C), described how my analysis of these results led to the formulation of a new set of hypotheses concerning the differences of PaSSAGE's effects on different subsets of players, and concluded by presenting the results of testing these new hypotheses.

# Chapter 6

# Discussion

In this chapter, I discuss PaSSAGE and my evaluation of its performance in three respects. I begin by discussing the results of my user study, and attempt to offer insight into why I received the results that I did. I then discuss how my user study was run, describing the problems and difficulties that I faced, and offering a set of lessons learned. Finally, I present PaSSAGE's limitations as a player-informed interactive storytelling AI and suggest ways to address them with future work.

## 6.1 Discussion of Results

As I stated in Section 5.8, PaSSAGE's results across all players were inconclusive. However, my consideration of several different subsets of players yielded a few promising and intriguing results.

First, given the results for players having low prior video gaming experience who found the game easy to follow, one can state that for such players, PaSSAGE satisfies the first primary goal of storytelling with 91% confidence, the second primary goal of storytelling with 87% confidence, and the third primary goal of storytelling with 72% confidence (Result 8). Given that players only had sufficient time during the experiment to play through a single story one time, this study may not have been a fair test of the replay value of PaSSAGE's stories, as it may take more than one play for players to realize how their actions are influencing the course of the story.

One intriguing result concerns the interplay between Results 2 and 3. Both concern players who found the game easy to follow, but they differ in that the former concerns only players who had low prior video gaming experience, while the latter concerns only players who were experienced in playing video games. Curiously, both subsets have some of the highest confidence levels found across all subsets tested, but where one's confidence level is high, the other's is low. This divergence suggests that although PaSSAGE seems to satisfy the primary goals of storytelling for the former subset of players, their lack of experience may have led to different notions of what "engaging" means. Additionally, it seems that although the latter subset of players agreed that PaSSAGE's stories were more engaging than the fixed stories, they may not have all held the notion that engagement (or immersion) is an important aspect of their enjoyment of a game or their sense of agency therein.

The most intriguing result of my evaluation is related to Result 10. While the high confidence values across so many metrics is definitely encouraging, the mean values of enjoyment, replay value, and, to a lesser extent, agency, are the most interesting (Table 5.5); the results for the adaptive stories show a significant difference between the means of these three values for the two subsets of players considered, but this difference is absent from the results of the same test on the static stories (Table 5.6). In fact, the mean values for Fun and Replay Value in each subset of the static story comparison are equal within one percent. Given that the only difference between the two pairs of subsets used in the comparisons was the nature of the stories that the players experienced (static or adaptive), it follows that PaSSAGE was somehow responsible for unbalancing the ratings of its players in favour of those with low prior gaming experience who could still find the game to be easy to follow. From Result 10, it seems very likely that PaSSAGE's approach achieves the primary goals of storytelling for players who find the game easy to follow and have low prior gaming experience significantly better than it does for other kinds of players. One possible explanation for this result concerns PaSSAGE's method of selecting encounters; PaSSAGE always chooses the encounter to occur which holds the branch that best matches the values in the player model at the time that the encounter is selected, thereby providing the player with an opportunity to play in their modelled style. Given that the strategy of most story-based video games is to include a wide variety of static content in an attempt to appeal to a broad range of player types, it may be the case that experienced players have become accustomed to always being presented with different (though potentially less desirable) types of story content, while inexperienced players, not having been influenced by the style of current games, might be more appreciative when a story's events are tailored to match their modelled style.

## 6.2 The User Study: Problems, Difficulties, and Lessons Learned

During the course of my user study, a small number of problems and difficulties arose, arising primarily from the limitations of the *Neverwinter Nights* game engine. Following the presentation of these issues, I offer a few of the lessons that I learned during the course of the study.

### 6.2.1 Problems

One major problem that occurred during the study was that for some players, the story that they were experiencing ended roughly sixty seconds before it was scripted to do so. After significant investigation of the scripts that were active at the time that the error occurred, I concluded that my scripts were not the source of the error. Further investigation has suggested that the *Neverwinter Nights* game engine may be sensitive to having to compete for system resources with other processes, resulting in script statements being executed in orders other than the one that was specified. Having no solution to this problem, I used the game's automatically generated logs to detect when this error occurred, and discarded the data that was obtained from every participant that was affected.

Another problem that occurred was that some players had such little interest in the content of the introductory history lesson (Section 5.3.1) that they quickly clicked on the first line of dialogue at every opportunity without reading any of the text (I detected this behaviour by reviewing the videos that were captured during the game). Because PaSSAGE builds much of its player model based on the player's decisions during this history lesson, I discarded the data that I obtained from players who took this action.

### 6.2.2 Difficulties

One difficulty that I encountered during the study was that some players could not find their way around the game environment well enough to progress through the game's story at a satisfactory pace, leading a small number of players to abandon their participation in the study part way through. I did not collect any data from players who abandoned their participation, and I retained the data from players who had difficulty but remained to complete their participation, assuming that their experience would influence their rating for the 'Easy to Follow' metric of the post-game survey.

Another difficulty that occurred was that my notion of the meanings of the metrics listed on the post-game survey, including my view of which of the two opposing terms for each metric was more desirable, was not shared by all players. For example, in the survey's optional comment section, some players indicated that they were disappointed that they had been able to predict what would happen at the end of the story (metric: Surprising/Predictable), while other players *enjoyed* the same ability. Although the Surprising/Predictable metric showed the only example of this inconsistency, similar problems may have occurred concerning other metrics as well.

### 6.2.3 Lessons Learned

I learned many lessons during the course of running my user study. For one, when the group of participants is large, having more than one experimenter present is invaluable, both for higher throughput in interacting with participants, and for speeding up the logistics of setting up and concluding each session of participation. Having captured videos of each of the players' experiences also proved to be invaluable, as these videos proved to be vital in ensuring that my study only considered data from participants who experienced an error-free story in one of the three versions of our storyworld (Section 5.4).

## 6.3 PaSSAGE: Limitations, Challenges, and Future Work

As it is currently implemented, PaSSAGE still has several limitations and challenges to overcome. I discuss these issues in the following sections, suggesting ways in which they might be addressed.

### 6.3.1 Plot Consistency

A major limitation of PaSSAGE at present is that it lacks an automatic way to maintain plot consistency; the author must manually create and maintain values as part of the Storyworld State to track what has happened thus far, and this process can be very prone to errors. For example, in our evaluation storyworld, Vero Willian can play roles in two potential encounters: Traveller in Need, and Wizard vs. Villain. When the Wizard greets the player in the latter encounter, to remain consistent, his dialogue must depend on whether or not he and the player have already met in the former encounter (*e.g.* "*Hello again, young lass. That was quite a noise you made just then!*" versus "*...and you must be the young lass whose scream I heard.*"). Using a centralized system for knowledge representation could ease the authorial burden of maintaining plot consistency considerably, allowing information relevant to the story to be tracked automatically and referred to in a standardized way.

### 6.3.2 Story Planning with Player Prediction

During Encounter Selection, PaSSAGE makes no consideration of the encounters that may follow the one that it is about to select. When the branches of a selected encounter lead to different resulting states of the storyworld, it may be the case that choosing one branch in the current encounter prevents (to maintain consistency) the selection of an encounter that would be highly desirable to the player, based on the current player model. To avoid this situation, the ability to *plan* a sequence of encounters for the story is required, as in Barber and Kudenko's work[5]. Representing PaSSAGE's encounters as planning operators (with preconditions, actions, and effects) is a necessary step toward achieving this goal.

### 6.3.3 Author Uncertainty in Annotations

PaSSAGE's model currently tracks only one value for each style of play: the strength of the player's inclination, disinclination, or indifference toward playing in that style. These values are updated based on the author's annotations on potential player actions, and used alongside the author's annotations on each encounter branch to determine which encounter to select. This strategy assumes that every author will be able to state with certainty both which actions indicate which types of players, and which types of players will enjoy, not enjoy, or be indifferent toward playing through each branch of every encounter in the storyworld. A different, more robust strategy would be to allow the author to additionally indicate any uncertainty that they may have in their annotations, and incorporate this uncertainty into PaSSAGE's Encounter Selection.

### 6.3.4 Extended Evaluation

The evaluation that I presented in Chapter 5 tested only part of PaSSAGE's technology. Although the functions that implemented both Encounter Specification and Encounter Refinement were active, they were not used to their full effect, in that the location of every encounter was predetermined

(aside from the Monster attack), and the sets of actors who satisfied the conditions for taking on each encounter's roles included only one actor per set (*e.g.* Vero Willian was always the traveller in the Traveller in Need encounter). I neglected taking advantage of these features in the interest of simplifying both the maintenance of plot consistency (Section 6.3.1) and the preservation of various aesthetic aspects of the story presentation (*e.g.* cinematic sequences showing a particular location in the world). Recent work in automatic cinematography seems promising toward addressing the latter concern [13]. Finding ways to address these issues is necessary before a full evaluation of PaSSAGE's abilities can be performed.

# Chapter 7

# Conclusion

In this dissertation, I explored the notion of Player-informed Interactive Storytelling: a means of interactively telling an interactive story in which the storyteller's deliberations over subsequent story events are focused on attending to the feedback that its audience presents. I began by introducing the primary goals of storytelling as a means of entertainment, and distinguished between two types of storyteller/audience interaction to motivate my approach. I presented the challenges of Player-informed Interactive Storytelling and used them to suggest the five core components of a player-informed interactive storytelling AI, upon which I based my discussion of related Interactive Storytelling techniques. Following a set of design ideals for the creation of a player-informed interactive storytelling AI in the context of a single-player, commercial video game, I presented PaSSAGE (Player-Specific Stories via Automatically Generated Events), the player-informed interactive storytelling AI that I implemented as the basis of this work. By automatically observing its players' actions to build a model of their preferred styles of play, PaSSAGE is able to dynamically select the content of an interactive story and provide opportunities for its players to play in the styles that they prefer. I described my evaluation of PaSSAGE's storytelling abilities through a controlled human user study, wherein 101 participants played through one of three variants of a storyworld: one with a static linear story, one with a static branching story, and the third with a personalized, adaptive story told through PaSSAGE's player-informed techniques. I presented a set of limitations and challenges that PaSSAGE has yet to overcome, and suggested directions for future work. By comparing PaSSAGE's adaptive, player-specifc stories to the two static stories via ratings on a post-game survey, I found that for players with low prior experience playing video games who rated their story experience as being easy to follow, PaSSAGE satisfied the primary goals of storytelling with the following levels of confidence: with 72% confidence, PaSSAGE's stories had better replay value, with 87% confidence, PaSSAGE's stories provided a better sense of agency, and with 91% confidence, PaSSAGE's stories were more fun.

# Glossary

**Agency:** A measure of the viewer's feeling of having influence over their story experience., 2

**Deliberative Interactivity:** A means of human/computer interaction in which the actions of the human user inform the computer's consideration of multiple potential reactions., 13

**Encounter:** An event in a story that directly involves the player (*e.g.* meeting a traveller in need is an encounter, but two distant nations going to war is not)., 36

**Enjoyment:** A measure of the pleasure that a viewer feels while experiencing a story's events., 2

**Global Structure:** The degree to which the events of a story are interrelated by causality; a story with strong global structure has highly interrelated events., 3

**Immersion:** A measure of how engrossed an audience is in the events of their story experience., 3

**Player-informed Interactive Storytelling:** A type of Interactive Storytelling in which the interaction between the storyteller and its player is characterized by *deliberative interactivity*., 14

**Plot Consistency:** A measure of the plausibility of the relationships between the events that occur in a story. The more fantastic a relationship is, the more it must be supported by fantastic means, toward maintaining the audience's *suspension of disbelief*., 3

**Reactive Interactivity:** A means of human/computer interaction in which the action of the human user directly triggers the computer's only potential reaction., 13

**Replay Value:** A measure of the viewer's willingness to experience a story (or perhaps variations thereof) multiple times., 2

**Suspension of Disbelief:** The willingness of an audience to believe in the events of their (fictional) story experience, even when those events would be implausible in the real world (*e.g.* "*Suddenly, a ball of light leapt from the wizard's hands and struck the troll in the chest.*")., 3

**Transparent Authoring Process:** A means of creating events for an interactive story in which it is readily apparent both when and why each event might occur., 38

# Bibliography


[1] ScriptEase Research Group, University of Alberta. http://games.cs.ualberta.ca/~script/, 2007.

[2] Gustavo Andrade, Geber Ramalho, Alex Sandro Gomes, and Vincent Corruble. Dynamic game balancing: an evaluation of user satisfaction. In *2nd Artificial Intelligence and Interactive Digital Entertainment Conference (AIIDE 2006)*, Marina del Rey, California, June 20-23 2006. AAAI Press.

[3] Ruth Aylett, Sandy Louchart, João Dias, Ana Pavia, and Marco Vala. FearNot! - an experiment in emergent narrative. In *IVA 2005, Lecture Notes in Computer Science*, volume 3661, pages 305–316, Kos, Greece, September 12-14 2005. Springer.

[4] Albert Bandura. Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, 52:1–26, 2001.

[5] Heather Barber and Daniel Kudenko. Dynamic generation of dilemma-based interactive narratives. In *3rd Artificial Intelligence and Interactive Digital Entertainment Conference (AIIDE 2007)*, Palo Alto, California, June 6-8 2007. AAAI Press.

[6] Heather Barber and Daniel Kudenko. A user model for the generation of dilemma-based interactive narratives. Technical report, AIIDE 2007 Workshop on Optimizing Player Satisfaction, Palo Alto, California: AAAI Press, June 2007.

[7] BioWare Corp. Aurora Neverwinter Toolset. http://nwn.bioware.com/, January 2006.

[8] Colin Campbell. The Games People Buy: Next Generation - Interactive Entertainment Today. http://www.next-gen.biz/ index.php?option=com_content&task=view&id=4691 &Itemid=46&limit=1&limitstart=0, 2007.

[9] Joseph Campbell. *The Hero with a Thousand Faces*. Princeton University Press, 1949.

[10] Chris Crawford. *Chris Crawford on Interactive Storytelling*. New Riders, 2005.

[11] Mihály Csíjszentmihályi. *Flow: The Psychology of the optimal experience*. Harper and Row, New York, 1990.

[12] The Oxford English Dictionary. *Various definitions*. OED Online. Oxford University Press, 2nd edition, 1989. http://dictionary.oed.com/, 2007.

[13] David K. Elson and Mark O. Riedl. A lightweight intelligent virtual cinematography system for machinima production. In *3rd Artificial Intelligence and Interactive Digital Entertainment Conference (AIIDE 2007)*, Palo Alto, California, June 6-8 2007. AAAI Press.

[14] Hector Gómez-Gauchía and Federico Peinado. Automatic customization of non-player characters using players temperament. In *3rd International Conference on Technologies for Interactive Digital Storytelling and Entertainment (TIDSE 2006)*, pages 1–12, Darmstad, Germany, December 4-6 2006. Springer.

[15] Jacob Grimm and Wilhelm Grimm. Little red cap. In *Kinder- und Hausmärchen, 1st ed*, volume 1. Berlin, 1812.

[16] Ian D. Horswill and Robert Zubek. Robot architectures for believable game agents. Technical report, 1999 AAAI Spring Symposium on Artificial Intelligence and Computer Games, Palo Alto, California, March 22-24 1999.

[17] Brenda Laurel. *Computers as Theatre*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 1991.

[18] Robin Laws. Robin's laws of good GMing. Steve Jackson Games, 2001.

[19] Brian Magerko. *Player Modeling in the Interactive Drama Architecture*. PhD thesis, Computer Science and Engineering, University of Michigan, 2006.

[20] Michael Mateas. *Interactive Drama, Art, and Artificial Intelligence*. PhD thesis, School of Computer Science, Computer Science Department, Carnegie Mellon University, 2002.

[21] 2K Boston/2K Australia. Bioshock. http://www.2kgames.com/bioshock/, 2004.

[22] beepa. Fraps. http://www.fraps.com/, 2007.

[23] Bethesda Softworks. The Elder Scrolls IV: Oblivion. http://www.elderscrolls.com/games/oblivion_overview.htm, 2006.

[24] BioWare Corp. Star Wars: Knights of the Old Republic. http://www.lucasarts.com/products/swkotor/, 2003.

[25] BioWare Corp. Neverwinter Nights. http://nwn.bioware.com/, 2006.

[26] Electronic Arts. SimCity 4. http://simcity.ea.com/, 2003.

[27] Electronic Arts. The Sims. http://thesims.ea.com/index_flash.php, 2004.

[28] Electronic Arts. The Sims Life Stories. http://thesims2.ea.com/about/sims_stories/index.php, 2007.

[29] Lionhead Studios. Black & White. http://www.lionhead.com/bw/, 2001.

[30] Lionhead Studios. Fable. http://fable.lionhead.com/, 2004.

[31] Brian Mac Namee, Simon Dobbyn, Pádraig Cunningam, and Carol O'Sullivan. Simulating virtual humans across diverse situations. Technical report, Computer Science Department, University of Dublin, Trinity College, Dublin 2, Ireland, 2003.

[32] Mindscape. Trust & Betrayal: The Legacy of Siboot. http://www.erasmatazz.com/free.html, 1987.

[33] MonoMyth.org. Joseph Campbell's MonoMyth (Hero's Journey). http://monomyth.org/?page_id=32, 2007.

[34] Nintendo. Wii. http://wii.nintendo.com/, 2006.

[35] Obsidian Entertainment. Neverwinter Nights 2. http://www.atari.com/nwn2/, 2006.

[36] Procedural Arts. Façade. http://www.interactivestory.net/, 2007.

[37] Ritual Entertainment. SiN Episodes: Emergence. http://www.sinepisodes.com/, 2006.

[38] Magy Seif El-Nasr. Interaction, narrative, and drama creating an adaptive interactive narrative using performance arts theories. *Interaction Studies*, 8(2), August 2007. To appear.

[39] Simtropolis - Online Community for SimCity 4 and SimCity Societies. Simtropolis Exchange. http://www.simtropolis.com/stex/index.cfm?page=1, August 2007.

[40] TIDSE. The authoring process in interactive storytelling. Pre-Conference Demo Workshop - 3rd International Conference on Technologies for Interactive Digital Storytelling and Entertainment, December 2006.

[41] Valve Corporation. Half-life 2. http://www.half-life2.com/, 2004.

[42] Robert McKee. *Story: Substance, Structure, Style, and the Principles of Screenwriting*. HarperCollins, New York, 1997.

[43] Mark J. Nelson, Michael Mateas, David L. Roberts, and Charles L. Isbell. Declarative optimization-based drama management in interactive fiction. *IEEE Computer Graphics and Applications*, 26(3):33–41, 2006.

[44] Federico Peinado and Pablo Gervás. Transferring game mastering laws to interactive digital storytelling. In *2nd International Conference on Technologies for Interactive Digital Storytelling and Entertainment (TIDSE 2004)*, pages 1–12, Darmstad, Germany, December 4-6 2004. Springer.

[45] Mark O. Riedl and Andrew Stern. Believable agents and intelligent story adaptation for interactive storytelling. In *3rd International Conference on Technologies for Interactive Digital Storytelling and Entertainment (TIDSE 2006)*, pages 1–12, Darmstad, Germany, December 4-6 2006. Springer.

[46] Richard M. Ryan and Edward L. Deci. Self-determination theory and the facilitation of intrinsic motivation, social development, and well being. *American Psychologist*, 55:66–78, 2000.

[47] Richard M. Ryan, C. Scott Rigby, and Andrew Przybylski. The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion*, 30:347–363, 2006.

[48] Manu Sharma, Manish Mehta, Santiago Ontañón, and Ashwin Ram. Player modeling evaluation for interactive fiction. Technical report, AIIDE 2007 Workshop on Optimizing Player Satisfaction, Palo Alto, California: AAAI Press, June 2007.

[49] Pieter Spronck, Marc Ponsen, Ida Sprinkhuizen-Kuyper, and Eric Postma. Adaptive game AI with dynamic scripting. *Machine Learning*, 63(3):217–248, 2006.

[50] David Thue, Vadim Bulitko, Marcia Spetch, and Eric Wasylishen. Interactive storytelling: A player modelling approach. In *3rd Artificial Intelligence and Interactive Digital Entertainment Conference (AIIDE 2007)*, Palo Alto, California, June 6-8 2007. AAAI Press.

[51] David Thue, Vadim Bulitko, Marcia Spetch, and Eric Wasylishen. Learning player preferences to inform delayed authoring. Technical report, AAAI Symposium on Intelligent Narrative Technologies, Arlington, Virginia, November 2007.

[52] Twentieth Century Fox. Star Wars Trilogy, 1977-1983.

[53] Warner Bros. The Matrix Trilogy, 1999-2003.

# Appendix A

# User Study Materials

UNIVERSITY OF ALBERTA
FACULTIES OF ARTS, SCIENCE & LAW
RESEARCH ETHICS BOARD

# *Application for Ethical Review of Research Involving Human Participants*

**Instructions:**

1. Use this form to request ethics review for research involving human subjects that does not require the use of identifiable health information. Human research that does involve identifiable health information should be submitted directly to the Health Research Ethics Board, http://www.hreb.ualberta.ca . Once the HREB review is completed, two (2) copies of the application together with HREB approval letter should be forwarded to the ASLREB Science member indicated below in (2).
2. Submit two (2) copies of this form together with supporting materials (questionnaire instruments, interview questions, consent forms, recruitment materials, debriefing forms, safety approvals, etc.) to the ASLREB member, Tom Johnson or Don Kuiken, Department of Psychology, P-217 Biological Sciences Building. If you intend to use the Psychology Subject Pool, a separate application together with description of your substitute exercise and debriefing must be submitted to Sharon Randon in the Department of Psychology.

## A. Project Information:

Submission Date: December 13, 2006

Project Title: Evaluating Entertainment for Adaptive Interactive Stories

## B. Applicant Information:

| | | | |
|---|---|---|---|
| Name: | **David Thue** | E-Mail: | **dthue@cs.ualberta.ca** |
| Department: | **Computing of Science** | Phone: | **780 492 2821** |
| Mailing Address: | **Department of Computing Science, ATH-221, University of Alberta** | | |

Are you: ☐ Faculty ☐ Staff ☒ Graduate Student ☐ Honors Student ☐ Undergraduate Student

*If you are a student:*

| | | | |
|---|---|---|---|
| Academic Supervisor: | **Vadim Bulitko** | E-Mail: | **bulitko@ualberta.ca** |
| Department: | **Computing Science** | Phone: | **780 492 3854** |

*If you are Not a member of the Department of Psychology*

| | | | |
|---|---|---|---|
| Name of Psychology Department Sponsor | **Marcia L. Spetch** | E-Mail: | **mspetch@ualberta.ca** |
| Institutional Affiliation | **Department of Psychology** | Phone: | **780 492 7548** |
| Mailing Address: | **Department of Psychology, P217 Biological Sciences Bldg, University of Alberta** | | |

**Other Investigators on this project**

| | Name | Institutional Affiliation /Department | E-mail address |
|---|---|---|---|
| 1. | **Vadim Bulitko** | **Department of Computing Science** | **bulitko@ualberta.ca** |
| 2. | **Marcia L. Spetch** | **Department of Psychology** | **mspetch@ualberta.ca** |
| 3. | | | |

## C. Project Type

***For the items below, please check all that apply:***

Project Type: ☐ Staff ☐ Student ☐ Class Project ☐ Grant Proposal ☒ Thesis ☐ In Class Research
☐ Quality Assurance ☐ Secondary Analysis of Data ☐ Mass Testing ☐ Subject Pool

ASLREB

Funding: ☐ AHFMR ☐ CIHR ☒ NSERC (via Marcia Spetch) ☐ SSHRC ☐ UofA Internal
☐ Other (specify):

**D. Signatures**

Your signature indicates that you agree to abide by all policies, procedures, regulations and laws governing the ethical conduct of research involving humans as described in GFC 66, http://www.uofaweb.ualberta.ca/gfcpolicymanual/content.cfm?ID_page=37738

Applicant: _____ Date:

**The signature of the Supervisor/Sponsor below indicates that they have reviewed and approved the proposal.**

Academic Supervisor: _____ Date:

Sponsor: _____ Date:

**E. Project Details**

1. Please provide a short summary of the project that describes the research objectives, principal methods employed, research participants, and hypotheses.

This research investigates a combination of player modelling and interactive storytelling in the context of computer video games. Player modelling is the task of automatically identifying the preferences of the player of a computer game by observing their actions in the game's virtual environment, while interactive storytelling is the process of telling a (fictional) story in such a way that feedback from the audience is used to alter the story's chain of events dynamically. The purpose of this research is to a) investigate whether a player's preferences can be automatically learned and used to dynamically adapt the storyline of a computer video game, and b) test our hypothesis that a dynamically adapting storyline will increase both the player's sense of personal agency and the entertainment value of the game. Participants will be required to complete only one task: playing through (i.e. experiencing through interaction with a computer) the first act of a story in a computer video game. Participants will be divided into two groups; Group A will play a game which learns player preferences and adapts its story accordingly, while Group B will play a visually similar game which performs no learning and selects subsequent story events corresponding to a predetermined plot (e.g., the fairly tale "Little Red Riding Hood"). Our primary hypothesis is that a game whose story adapts to the player's preferences will be found more entertaining (be ranked more highly) than a game that selects story events from a fixed, predetermined plot.

2. Describe the source of research participants. Indicate the manner in which participation will be solicited and the nature of any inducements or promises offered for participation. For secondary analysis of data, please describe the source and characteristics of the dataset.

The research participants will be initially solicited through the Psychology 104/105 research participant system. If more participants are required than this primary source can provide, additional participants will be solicited as follows. University of Alberta graduate and undergraduate students will be contacted via e-mail and/or posters (examples attached) inviting them and their fellow students to participate in the study. To compensate for their time spent completing the study, participants from this secondary source will each be given $10.00.

3. Describe the procedures to be used including the tasks and procedures involved in participating.

This study will be conducted at the University of Alberta in a computer lab in the Computing Science Centre. Upon entering the lab, each participant will be asked to read both a brief introduction to the study and a set of instructions explaining how to perform simple actions in the game environment. The participant will then be given training time in a small, representative version of the game environment to familiarize themselves with taking actions in the game; an experimenter will be available during this time to answer any questions that may arise. The process described thus far is expected to take no more than 10 minutes. Following the training phase, participants will be asked to play one of the two games in a single session lasting at most 30 minutes. Each game will consist of a sequence of events forming a short story. Playing the game will consist of moving the story's protagonist through a 3-D virtual environment that represents the world in which the story takes place. Possible player actions include engaging in dialogue (choosing from sets of statements and questions) with computer-controlled secondary characters, searching for and collecting items from containers, and defending against computer-controlled monsters (hostile creatures in a forest). Upon completing the game, all participants will be asked to complete a survey based on their age, gender, and the degree to which they enjoyed the game (see attached survey). Two groups will be needed for this experiment (groups A and B as described in Section 2); as such, we estimate that between 50 and 100 participants will be required.

For every participant, the following data will be collected:

1. The sequence of story events experienced by the participant.

2. The sequence of actions taken by the participant in-game.

3. The state of the automatically learned preference model after each event and action.

4. An exit survey (see attached) to be administered by a researcher.

4. Describe how you will deal with the issues of informed consent and continuing voluntariness of participation in the research. For minors, describe how you will obtain consent of guardians.

Participants will be asked to read both a brief, descriptive introduction to the study and a consent form. Only participants who complete and sign a consent form will participate in the study, and all participants will be informed that they may discontinue their participation at any point during the study and still receive course credit (or the honourarium for secondary-source participants). Those who choose to not participate will be given an alternate assignment to complete (see attached) requiring no more than 45 minutes of work (the estimated duration of the study).

5. Describe how you will grant anonymity to participants and how responses will be kept confidential. If names or other identifying information are coded with data, describe how access to data is limited and safeguarded. Indicate who will have access. If appropriate, describe how consent is obtained from participants for exceptions to anonymity/confidentiality (e.g., focus groups). If data are to be taken from existing sources, discuss the implications of pre-existing (implicit or explicit) guarantees of confidentiality/anonymity.

No names or other identifying information will be collected in the data, and only members of the research team will have access to the data.

6. Describe your plans for the retention and disposal of data.

All data collected will be stored securely on a computer in a restricted-access research lab for a minimum of five years.

7. If concealment and/or deception is to be employed, provide explicit justification. Indicate how and when participants will be informed of the concealment and/or deception.

To perform a valid assessment of the value of having a game's storyline adapt to the preferences of its player, participants who play the adaptive game will not be told that any adaptation will occur. The necessity of withholding this information arises from the fact that on-line adaptation is still a very new technology in the computer games industry, and believing that the game might adapt may bias the participants' ratings of the game on the survey. Upon completing the survey, participants will be given a full debriefing explaining the adaptive nature of one of the games.

8. Describe the nature of any risks to the physical or psychological well-being or integrity of participants that might arise from your procedures, and discuss your justifications, safeguards, and resolutions for these risks where appropriate.

There will be no dangerous substances or risks of physical harm.

The computer software we are using has been rated Teen by the Entertainment Software Rating Board (ESRB - see http://www.esrb.org/ratings/ratings_guide.jsp for details).

The following is a more detailed description of my computer game in terms of the types of content listed in the ESRB Teen rating:

Violence:

All violence portrayed in the game is shown using cartoon-like computer animation. Examples of the most intense scenes containing violence in my game include:

1) the player's character (a young human woman) fist-fighting with a monster (a green bridge troll, for example) and subsequently defeating it (it falls to the ground and remains prone), or

2) a computer-controlled character (a human man) using magic to defeat the monster (the monster turns into large blobs which fall to the floor), or

3) the monster "eating" either the player's character or a computer-controlled character (the monster grasps its victim, and the victim slowly vanishes while shaking).

Videos of in-game scenes containing these events can be viewed via the following link:

http://picasaweb.google.com/PaSSAGE.Storytelling/EthicsApprovalDemoVideos?authkey=RhTv2dAoxE0

Suggestive Themes: None.

Crude Humour: None.

Minimal Blood:

An example of the most intense depictions of "blood" is the large blobs shown during the monster's demise by magic.

Simulated Gambling: None.

Strong Language:

There are no swears or curse words used in my game. The strongest uses of language occur when the player provokes the troll into attacking; for example, the player might choose to say one of the following lines to the troll:

"Let me by troll, or I'll have your head!", or

"It sounds like the wizard has the right idea, trying to kill you and all."

9. Indicate when participants will be debriefed, and describe the nature and extent of debriefing. Indicate how participants may follow-up with researchers to ask questions or obtain information about the study.

All participants will be given a full debriefing upon completing the survey at the end of the experiment, during which the nature of the experiment and our hypothesis will be explained.

10. Describe any apparatus, element of the physical environment, substance or other materials that could cause harm to a participant if a malfunction, misuse, accident, allergic reaction, or side-effect were to occur. If the participant comes into contact with a potentially hazardous apparatus or material, who will be responsible for checking for defects/malfunctions, and on what schedule will inspections be made? If participants come into contact with some substance that could cause harm, please document your safeguards. Describe safety approvals that you have obtained or applied for (e.g., biohazards, electromechanical, radiation, etc.)

N/A

11. Describe qualifications of research personnel if special conditions exist within the research that could cause physical or psychological harm or if participants require special attention because of physical or psychological characteristics, or if made advisable by other exigencies.

N/A

12. Describe any potentially hazardous duties that will be required of research personnel, including physical, mental, or legal risks. Describe the safeguards you have implemented for your personnel.

N/A

Please submit two (2) copies of your application together with supporting materials to Dr. Tom Johnson or Dr. Don Kuiken, Department of Psychology, P-217 Biological Sciences Building.

| *FOR ASLREB USE ONLY:* | File Number: |
|---|---|
| Received Date | Review Type: ☐ Expedited ☐ Referred to Committee ☐ HREB |
| Meeting Date | |
| Approval Date: | |
| Reviewer | Date: |

## Introduction and Participants' Consent Form

**Introduction**. Welcome! You are invited to participate in a research study being conducted by David Thue and Dr. Vadim Bulitko of the Department of Computing Science and Dr. Marcia Spetch of the Department of Psychology, from the University of Alberta. The purpose of this study is to evaluate the quality and entertainment value of several *interactive stories* (video game experiences in which the player chooses the actions of the story's main character, thereby adjusting the course of the story).

**Your participation**. Your participation in this study involves experiencing a short interactive story by playing a computer video game for about 30 minutes. The events that form the story may include animated violence with minimal blood. Before beginning the story, you will be presented with a short set of instructions for interacting with the game environment, and given the opportunity to practice for 5 to 10 minutes. Following your completion of the story, you will be asked to fill out a survey ranking the game across several measures including whether you found the story interesting or boring, surprising or predictable, etc.

**Your rights**. Your decision to participate in this study is entirely voluntary and you may decide at any time to withdraw from the study. Your decision to discontinue will not affect your academic status or access to services from the University of Alberta. If you choose to participate, you may skip any items you do not wish to answer. Responses made by individual participants on the questionnaires will remain confidential, and your name will not appear on the questionnaire or be associated with your responses in any way. Questionnaires will be identified only by a researcher-assigned code number, for the purpose of associating survey forms with the particular story that the participant experienced. Only researchers associated with the project will have access to the questionnaires. The results of this study may be presented at scholarly conferences, published in professional journals, or presented in class lectures. All data presented will be anonymous. The data will be securely stored by (David Thue) for a minimum of five years.

**Benefits and risks**. There are no foreseeable risks to this study, but if any risks should arise, the researcher will inform the participants immediately. If you should experience any adverse effects, please contact David Thue and/or Dr. Vadim Bulitko immediately.

**Contact information**. If you have any questions or comments on the study, or if you wish a clarification of rights as a research participant, you can contact David Thue or the Human Research Ethics Committee at the number and address below.


***David Thue***
M. Sc. Candidate
Department of Computing Science
University of Alberta
Edmonton, AB T6G 2E8
(780) 492-2821

***Vadim Bulitko***, Ph.D.
Assistant Professor
Department of Computing Science
University of Alberta
Edmonton, AB T6G 2E8
(780) 492-3854

***Tom Johnson***, Ph.D.
Chair, Human Research Ethics Committee
Department of Psychology
University of Alberta
Edmonton, AB T6G 2E9
(780) 492-2834


**Signatures**. Please sign below to indicate that you have read and understood the nature and purpose of the study. Your signature acknowledges the receipt of a copy of the consent form as well as indicates your willingness to participate in this study.

| | |
|---|---|
| Participant's Signature | Date |
| Researcher's Signature | Date |

## Introduction and Participants' Consent Form

**Introduction.** Welcome! You are invited to participate in a research study being conducted by David Thue and Dr. Vadim Bulitko of the Department of Computing Science and Dr. Marcia Spetch of the Department of Psychology, from the University of Alberta. The purpose of this study is to evaluate the quality and entertainment value of several *interactive stories* (video game experiences in which the player chooses the actions of the story's main character, thereby adjusting the course of the story).

**Your participation.** Your participation in this study involves experiencing a short interactive story by playing a computer video game for about 30 minutes. The events that form the story may include animated violence with minimal blood. Before beginning the story, you will be presented with a short set of instructions for interacting with the game environment, and given the opportunity to practice for 5 to 10 minutes. Following your completion of the story, you will be asked to fill out a survey ranking the game across several measures including whether you found the story interesting or boring, surprising or predictable, etc. You will receive a $10 honourarium for your time.

**Your rights.** Your decision to participate in this study is entirely voluntary and you may decide at any time to withdraw from the study. If you choose to participate, you may skip any items you do not wish to answer. Responses made by individual participants on the questionnaires will remain confidential, and your name will not appear on the questionnaire or be associated with your responses in any way. Questionnaires will be identified only by a researcher-assigned code number, for the purpose of associating survey forms with the particular story that the participant experienced. Only researchers associated with the project will have access to the questionnaires. The results of this study may be presented at scholarly conferences, published in professional journals, or presented in class lectures. All data presented will be anonymous. The data will be securely stored by (David Thue) for a minimum of five years. If you choose to decline or discontinue your participation, we will accept your decision without question and without penalty, i.e., you will still receive the honorarium.

**Benefits and risks.** There are no foreseeable risks to this study, but if any risks should arise, the researcher will inform the participants immediately. If you should experience any adverse effects, please contact David Thue and/or Dr. Vadim Bulitko immediately.

**Contact information.** If you have any questions or comments on the study, or if you wish a clarification of rights as a research participant, you can contact David Thue or the Human Research Ethics Committee at the number and address below.


***David Thue***
M. Sc. Candidate
Department of Computing Science
University of Alberta
Edmonton, AB T6G 2E8
(780) 492-2821

***Vadim Bulitko***, Ph.D.
Assistant Professor
Department of Computing Science
University of Alberta
Edmonton, AB T6G 2E8
(780) 492-3854

***Tom Johnson***, Ph.D.
Chair, Human Research Ethics Committee
Department of Psychology
University of Alberta
Edmonton, AB T6G 2E9
(780) 492-2834


**Signatures.** Please sign below to indicate that you have read and understood the nature and purpose of the study. Your signature acknowledges the receipt of a copy of the consent form as well as indicates your willingness to participate in this study.

Participant's Signature _____ Date _____

Researcher's Signature _____ Date _____

# *Neverwinter Nights Gameplay Instructions*

Welcome to Neverwinter Nights! By reading these instructions, you will learn the skills necessary to participate in the wide range of interactive stories told in the Neverwinter Nights Game Engine. The Neverwinter Nights Game Engine is a computer software tool developed by BioWare Corp. which allows aspiring authors, artists, and programmers to create custom adventures in a virtual fantasy world. Playing these adventures amounts to **controlling the story's main character(s)** in terms of **where they go**, **what they do**, and **what they say during conversations**. Since many adventures try to put the player "in the shoes of" the main character, the following instructions refer to "you" as both the player the main character (i.e., "if you want to talk to a character, left-click on that character").

## Moving Around

| | |
|---|---|
| Description: | The most basic things to do – walk or run. |
| How: | **Left-click at the destination you wish to walk to.** If it worked, a green marker will appear and you will begin walking there. |
| Why: | The story would be pretty boring if you were stuck on the spot, no? |

## Starting a Conversation

| | |
|---|---|
| Description: | The second most basic thing to do – talk to someone. |
| How: | **Left-click on the character you wish to talk to.** If a friendly character has something to say, the *dialogue box* will appear in the upper-left corner of the screen, with the character's phrase shown near the top. (see next point) |
| Why: | Some characters might have valuable information to share. |

## Talking in a Conversation

| | |
|---|---|
| Description: | Talking in this game is represented by choosing between various pre-written lines of dialogue. |
| How: | During a conversation, the *dialogue box* is visible in the upper-left corner of the screen. Characters' phrases will appear near the top of the box, and a list of responding phrases for you to choose from will appear just below. **Left-click on the phrase you wish to say.** |
| Why: | Talking with characters is the best way to find out what's going on. |

**Defending Yourself**

| | |
|---|---|
| Description: | Not every creature you meet will be friendly, and some might even want to fight with you. |
| How: | Creatures that are unfriendly towards you will glow red if you point at them using the cursor, and the cursor will turn into a sword. **Left-click on the character you wish to attack**. You will continue to attack until your enemy falls or you perform a different action. |
| Why: | It may become necessary to defend yourself! |

**Using Doors**

| | |
|---|---|
| Description: | Doors can be opened and closed. |
| How: | ***Opening:*** **Left-click on the closed door you wish to open.**<br>***Closing:*** **Right-click on the open door you wish to close.** |
| Why: | Being stuck in a room wouldn't be much fun, would it? |

**Collecting Objects**

| | |
|---|---|
| Description: | Various objects exist in the world which can be picked up and carried around (e.g., a magic potion, a suit of armor, etc.). |
| How: | **Left-click on the object you wish to pick up.** |
| Why: | Valuable items may be left on the ground. |

*Game Story Evaluation*

**Age** (in years): ____ **Gender**: M F

For the following section, please choose a NUMBER between 1 and 5 to describe your opinion regarding the game story that you just experienced. Please circle only one number per statement. If you agree with the term on the left, circle 1. If you agree with the term on the right, circle 5. If you feel the story is somewhere in between these terms, circle a number between 1 and 5.

**Carefully read each pair of terms before circling your answer.**

---

**In comparison to an average video game of similar length that you've played in the past (or your expectation of one), how enjoyable was your game experience?**

| | | | | | | |
|---|---|---|---|---|---|---|
| Less Fun | 1 | 2 | 3 | 4 | 5 | More Fun |

---

**I felt as though my actions were influencing the story**

| | | | | | | |
|---|---|---|---|---|---|---|
| Never | 1 | 2 | 3 | 4 | 5 | Always |

---

**Overall, my interest in playing this game again is**

| | | | | | | |
|---|---|---|---|---|---|---|
| Low | 1 | 2 | 3 | 4 | 5 | High |

---

**In an average week, the amount of time I spend playing video games is:**

| | | | | | | |
|---|---|---|---|---|---|---|
| None at all | 1 | 2 | 3 | 4 | 5 | Greater than 10 hours |

---

**My experience playing this game was**

| | | | | | | |
|---|---|---|---|---|---|---|
| Interesting | 1 | 2 | 3 | 4 | 5 | Boring |
| Plausible | 1 | 2 | 3 | 4 | 5 | Implausible |
| Engaging | 1 | 2 | 3 | 4 | 5 | Shallow |
| Predictable | 1 | 2 | 3 | 4 | 5 | Surprising |
| Fascinating | 1 | 2 | 3 | 4 | 5 | Ordinary |
| Repetitive | 1 | 2 | 3 | 4 | 5 | Varied |
| Difficult to follow | 1 | 2 | 3 | 4 | 5 | Easy to follow |
| Creative | 1 | 2 | 3 | 4 | 5 | Conventional |

---

**Comments** (optional): Please write any comments you may have on the reverse of this page.

**Comments** (optional):

## *Debriefing*

***Evaluating Entertainment for Adaptive Interactive Stories***

Thank you for participating in this study! Your time and effort have been invaluable to us. Video games are an increasingly popular form of entertainment, but little is known about why people play video games and what gratifications they receive from them. Our research investigates whether personal agency influences the enjoyment experienced from playing a game. Specifically, we wondered whether a storytelling game that adapts to a player's behavior would be rated as being more enjoyable than one that follows a fixed storyline and is independent of the player's behavior. A great deal of previous research by Seligman and others has shown that a lack of personal control over aversive events is stressful, but little research has addressed the extent to which personal agency enhances enjoyment. To examine this, we created an automated storytelling system in which the story could automatically change depending on your actions and decisions in the game environment. Our independent variable is the presence or absence of adaptive learning by the game. If you were in the Control condition, the automatic adaptive system was turned off, and story events were chosen to follow a fixed, predetermined story (inspired by the Grimm Brothers' version of "Little Red Riding Hood"). If you were in the Experimental condition, the game automatically observed the actions that you took, and tried to learn your preferred way of playing. Based on this learned model, the game then chose events to occur that would allow you to continue to play in your preferred way, while still satisfying the overall structure of a heroic journey through a fantasy world. Thus, the Experimental condition provided personal agency over the events in the game whereas the Control condition did not. Our primary dependent variable was your rating of how enjoyable the game was on the questionnaire.

Our hypothesis is that players who experienced the automatically-adapting story would rate the game's entertainment value more highly than players who experienced the fixed original story. It was necessary to withhold the information that the game may adapt its story based on your actions because adaptive, "intelligent" technologies are still very new in the interactive entertainment industry, and knowledge of such a technology's presence in a game might bias your rating of the game's entertainment value. The results of this research will further understanding of the importance of personal agency and will provide knowledge about the factors that influence gratification and enjoyment of storytelling games. This information will be of theoretical interest to researchers in psychology and will have applied value for researchers in computer science.

Thanks very much for participating. Without the help of people like you, we couldn't answer most important scientific questions in psychology. You've been a great help. Do you have any questions that I can answer right now? If you have any questions, later on, about the study, please contact David Thue via either phone (492-2821) or e-mail (dthue@cs.ualberta.ca) or if you have general questions, contact Dr. Tom Spalding (Director, Research Participation) at rpdirect@ualberta.ca or 492-7778, or Sharon Randon (Research Participation Coordinator) at rescred@ualberta.ca or 492-5689. Please don't tell other people about what we had you do here because other students in the class may participate in this study.

## *Alternate Assignment*

**Instructions:**

This assignment asks for your comments on the subject of a short article. The article below discusses the subject of Interactive Storytelling, a medium for telling spontaneous fictional stories which are guided by audience interaction. To complete the assignment, you must both read the article and write a critical analysis of its content by providing answers to the questions given at the end of this document.

**Essay:**

### *Decisions in Interactive Storytelling*

*"Interactive storytelling in common man's terms is called Grandma."*

-- savagedome, slashdot.org

*"Yup. Any grandma who makes up stories is well versed in the technique of reaching a climactic moment and asking "And then what do you think happened?" The child responds, and grandma exclaims "That's exactly right!" Then grandma continues, dramatizing and expounding on the child's answer."*

-- dillon_rinker, slashdot.org

What is Interactive Storytelling? Even these informal comments taken from Slashdot, a popular on-line news service, offer an intuitive definition; Interactive Storytelling occurs when the storyteller (the grandmother) allows the audience (the grandchild) to contribute to the storytelling process by reacting to the story's events. By observing her grandchild's reactions, the grandmother can refine her story, always trying to ensure that the next part of the plot is just what the child is hoping for. Although the grandmother's options for extending the tale are limited only by her imagination, the child perceives only a single, hand-crafted stream of events, each chosen (by the grandmother) with the goal of telling the most enjoyable story possible.

Consider the same child fifteen years later. Having outgrown story-time with Grandma long ago, is his or her chance to experience interactive stories lost? Fortunately, a few alternatives exist.

Popularized in the mid-1970s, pen-and-paper role-playing games (RPGs) provide an Interactive Storytelling setting in which one player (designated the "Game Master") dynamically creates a shared, imagined experience for the members of his audience ("players"). Typically taking place in a fantasy world, each story evolves based on the players' interactions and reactions to story-events, which guide

the choices made by Game Master when deciding what should happen next. Unfortunately, pen-and-paper games are plagued by a number of problems, one of the most notable being the social-scheduling difficulties involved with telling a long, continuous story to a particular group of players; such stories often span many multi-hour sessions, and having even one player absent can severely hinder any meaningful progress in the story.

Another form of media that provides a form of Interactive Storytelling experience is the "Choose Your Own Adventure" series of novels published by Bantam Books from 1979 to 1998. Each page in a Choose Your Own Adventure novel describes (and often illustrates) a brief sequence of events in second person, placing the reader in the role of the story's protagonist. Following each description of events, the reader is presented with a set of possible actions for his or her character to take, where choosing a particular action instructs the reader to turn to a predetermined page in the book that describes the outcome of that choice. With varied choices of the protagonist's actions, multiple stories can be experienced, often with drastically different endings. Although allowing the reader to make story-related decisions provides some degree of interactivity, Choose Your Own Adventure novels are limited by the fact that every *storyteller* decision has already been made; turning to a particular page will always result the same event occurring, and the author can only hope that this event will be satisfying to the reader.

A relatively recent attempt at Interactive Storytelling exists in the computer video gaming industry, most often resulting in the creation of "computer role-playing games". In such games, a single player chooses the actions of the story's protagonist in a virtual world, presented via audio/visual elements similar to those in an animated movie. In the virtual world, non-player characters that play roles vital to the story are controlled by the computer; this helps to avoid the scheduling problems inherent in multi-player pen-and-paper role-playing games. Similar to Choose Your Own Adventure novels, different player actions result in different stories being told. However, each potential sequence of events remains predetermined; once the game is released, its success depends entirely on the game authors/writers' skill at having correctly guessed what their prospective players would enjoy.

Toward solving the problems inherent in the forms of Interactive Storytelling given above, consider the following hypothetical scenario, wherein the pen-and-paper and computer variants of role-playing games are combined in a novel way. Between pen-and-paper and computer RPGs, two primary differences exist: the distinction between author and storyteller, and the timing of the author's

decisions. In computer RPGs, a human author crafts a story which a computer then tells, and all author decisions are made beforehand using best-guesses about player satisfaction. In pen-and-paper RPGs, a human author *is* the storyteller (the "Game Master"), allowing author decisions to remain open to alteration *during* the telling of the story. As requiring the presence of a Game Master is undesirable for reasons given previously, a beneficial combination of these ideas would be to postpone the computer RPG author's decisions to the time at which the story is being told, giving the computer the ability to make and alter story-related decisions as the story unfolds. Drawing an analogy from the domain of Choose Your Own Adventure novels, the proposed system would be akin to reading a novel in which the page numbers linked with reader actions are decided *after* the reader chooses which action to take, based on the sequence of choices he or she made thus far in the story. The key to constructing a successful automated storytelling system lies in giving it the power to correctly make author decisions; that is, it must store an author's knowledge in computerized form. That is, the computer must be able to answer two questions: *"what events can occur?"*, and *"how might different kinds of players behave if those events happened?"* Given answers to these questions, a computer could automatically observe a player's reactions to in-game events and learn a model of their personality and preferred styles of play. Using this model, subsequent story-events could be chosen that allowed players to play in their preferred fashion, improving satisfaction on a player-by-player basis. The proposed combination of pen-and-paper and computer role-playing games presents a new way forward for Interactive Storytelling, and by delaying author decisions for as long as possible, truly interactive stories can be told.

**Questions:**

1. In your own words, write two or three sentences that describe Interactive Storytelling.

2. In at most one paragraph, discuss any forms of Interactive Storytelling that you are aware of which are not discussed in the article.

3. In one paragraph, relate your opinion on the hypothetical automated storytelling system proposed in the article, *from the perspective of a potential player*. Would you want to play a game that used the proposed system? Do you think that you would enjoy playing such a game?

4. In one paragraph, relate your opinion on the hypothetical automated storytelling system proposed in the article, *from the perspective of a potential author*. Would you want to create content for the proposed system? Do you think that the system could effectively postpone your decisions concerning what should happen next in the story?

ARE YOU GAME?

To help evaluate an ongoing research project, we are inviting *female gamers* to participate in a user study on storytelling in games. If you're a female who typically plays video games for two or more hours each week, please consider participating in this study. The study will take place in a computer lab in the Computing Science Centre, lasting 30-50 minutes. To compensate for this time, participants will receive a small honourarium.

For more information, send an e-mail to: storytesting@gmail.com

This study has been reviewed and approved by the Human Research Ethics Board at the University of Alberta.

# Appendix B

# Detailed Evaluation Results: Stage 1

As mentioned in Section 5.8, confidence values are omitted for metrics whose values were used to select the subset of players being considered.

| All Players | | | |
|---|---|---|---|
| $N_A$: 43, $N_S$: 43 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2093 | 3.1163 | 67 |
| **Agency** | 3.7907 | 3.6744 | 68 |
| **Replay Value** | 3.186 | 3.2558 | 39 |
| **Gaming Experience** | 2 | 1.7674 | 79 |
| **Interesting** | 3.6279 | 3.6977 | 37 |
| **Plausible** | 3.3023 | 3.3488 | 39 |
| **Engaging** | 3.5581 | 3.4884 | 61 |
| **Surprising** | 2.8372 | 2.8837 | 42 |
| **Fascinating** | 3.0698 | 3.0698 | 50 |
| **Varied** | 3.3488 | 3.4186 | 38 |
| **Easy to Follow** | 4.3721 | 4.4186 | 40 |
| **Creative** | 3.2093 | 3.3023 | 36 |

Table B.1: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively.

| Easy to Follow ($\geq 4$) | | | |
|---|---|---|---|
| $N_A$: 35, $N_S$: 37 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2857 | 3.0811 | 82 |
| **Agency** | 3.8 | 3.6486 | 71 |
| **Replay Value** | 3.2857 | 3.2703 | 52 |
| **Gaming Experience** | 2.1714 | 1.8378 | 85 |
| **Interesting** | 3.7143 | 3.7027 | 51 |
| **Plausible** | 3.4286 | 3.4054 | 54 |
| **Engaging** | 3.6857 | 3.5405 | 72 |
| **Surprising** | 2.8 | 2.7838 | 52 |
| **Fascinating** | 3.0571 | 3.027 | 54 |
| **Varied** | 3.3429 | 3.3784 | 44 |
| **Easy to Follow** | 4.8 | 4.7027 | - |
| **Creative** | 3.2571 | 3.2162 | 55 |

Table B.2: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players who rated the game as being easy to follow.

| Females | | | |
|---|---|---|---|
| $N_A$: 31, $N_S$: 36 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2903 | 3.0833 | 80 |
| **Agency** | 3.9355 | 3.6667 | 84 |
| **Replay Value** | 3.2903 | 3.25 | 55 |
| **Gaming Experience** | 1.3548 | 1.5833 | 15 |
| **Interesting** | 3.6129 | 3.7222 | 33 |
| **Plausible** | 3.3226 | 3.3333 | 47 |
| **Engaging** | 3.5806 | 3.5556 | 53 |
| **Surprising** | 2.8387 | 2.9444 | 34 |
| **Fascinating** | 3.0323 | 3.0556 | 46 |
| **Varied** | 3.4516 | 3.4167 | 55 |
| **Easy to Follow** | 4.3226 | 4.4167 | 35 |
| **Creative** | 3.2903 | 3.2222 | 58 |

Table B.3: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players.

| Males | | | |
|---|---|---|---|
| $N_A$: 11, $N_S$: 6 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.0909 | 3.1667 | 43 |
| **Agency** | 3.3636 | 3.6667 | 30 |
| **Replay Value** | 3 | 3.1667 | 35 |
| **Gaming Experience** | 3.6364 | 2.6667 | 89 |
| **Interesting** | 3.8182 | 3.5 | 76 |
| **Plausible** | 3.1818 | 3.3333 | 36 |
| **Engaging** | 3.5455 | 3.1667 | 74 |
| **Surprising** | 2.7273 | 2.5 | 62 |
| **Fascinating** | 3.0909 | 3 | 56 |
| **Varied** | 3.1818 | 3.3333 | 40 |
| **Easy to Follow** | 4.5455 | 4.3333 | 71 |
| **Creative** | 3 | 3.5 | 15 |

Table B.4: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players.

| Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 32, $N_S$: 32 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.3125 | 3.0625 | 85 |
| **Agency** | 4 | 3.6562 | 91 |
| **Replay Value** | 3.3438 | 3.1875 | 69 |
| **Gaming Experience** | 1.25 | 1.1562 | - |
| **Interesting** | 3.7188 | 3.6562 | 59 |
| **Plausible** | 3.3125 | 3.3125 | 50 |
| **Engaging** | 3.5312 | 3.5312 | 50 |
| **Surprising** | 2.75 | 2.9062 | 29 |
| **Fascinating** | 3.125 | 2.9375 | 75 |
| **Varied** | 3.4688 | 3.4688 | 50 |
| **Easy to Follow** | 4.2188 | 4.4062 | 23 |
| **Creative** | 3.2812 | 3.3438 | 42 |

Table B.5: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience.

| Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 19, $N_S$: 16 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.1579 | 3.0625 | 62 |
| **Agency** | 3.6842 | 3.625 | 55 |
| **Replay Value** | 3.0526 | 3.3125 | 26 |
| **Gaming Experience** | 3.2632 | 3.0625 | - |
| **Interesting** | 3.6316 | 3.75 | 35 |
| **Plausible** | 3.3684 | 3.4375 | 40 |
| **Engaging** | 3.5263 | 3.1875 | 79 |
| **Surprising** | 2.7895 | 2.75 | 53 |
| **Fascinating** | 3.1053 | 3.1875 | 40 |
| **Varied** | 3.2105 | 3.25 | 46 |
| **Easy to Follow** | 4.4211 | 4.5625 | 31 |
| **Creative** | 3 | 3.1875 | 31 |

Table B.6: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience.

| Females, Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 28, $N_S$: 29 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2857 | 3.0345 | 83 |
| **Agency** | 4 | 3.6552 | 89 |
| **Replay Value** | 3.3571 | 3.1724 | 71 |
| **Gaming Experience** | 1.1429 | 1.1379 | - |
| **Interesting** | 3.6786 | 3.6897 | 48 |
| **Plausible** | 3.3214 | 3.3103 | 51 |
| **Engaging** | 3.5357 | 3.6552 | 35 |
| **Surprising** | 2.8214 | 2.9655 | 31 |
| **Fascinating** | 3.0714 | 2.9655 | 64 |
| **Varied** | 3.5 | 3.4828 | 52 |
| **Easy to Follow** | 4.25 | 4.4138 | 27 |
| **Creative** | 3.3214 | 3.2759 | 55 |

Table B.7: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience.

| Females, Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 7, $N_S$: 11 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.4286 | 3.0909 | 76 |
| **Agency** | 4.1429 | 3.6364 | 80 |
| **Replay Value** | 3.2857 | 3.4545 | 40 |
| **Gaming Experience** | 2.5714 | 2.9091 | - |
| **Interesting** | 3.5714 | 3.8182 | 29 |
| **Plausible** | 3.5714 | 3.3636 | 70 |
| **Engaging** | 3.5714 | 3.1818 | 71 |
| **Surprising** | 2.7143 | 2.7273 | 48 |
| **Fascinating** | 3 | 3 | 50 |
| **Varied** | 3.4286 | 3.0909 | 73 |
| **Easy to Follow** | 4.2857 | 4.5455 | 31 |
| **Creative** | 3 | 2.9091 | 55 |

Table B.8: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience.

| Males, Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 4, $N_S$: 3 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.5 | 3.3333 | 59 |
| **Agency** | 4 | 3.6667 | 71 |
| **Replay Value** | 3.25 | 3.3333 | 46 |
| **Gaming Experience** | 2 | 1.3333 | - |
| **Interesting** | 4 | 3.3333 | 85 |
| **Plausible** | 3.25 | 3.3333 | 42 |
| **Engaging** | 3.5 | 2.3333 | 86 |
| **Surprising** | 2.25 | 2.3333 | 46 |
| **Fascinating** | 3.5 | 2.6667 | 79 |
| **Varied** | 3.25 | 3.3333 | 46 |
| **Easy to Follow** | 4 | 4.3333 | 33 |
| **Creative** | 3 | 4 | 10 |

Table B.9: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with low prior video-gaming experience.

| Males, Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 11, $N_S$: 4 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.0909 | 2.75 | 74 |
| **Agency** | 3.3636 | 3.5 | 42 |
| **Replay Value** | 3 | 2.75 | 69 |
| **Gaming Experience** | 3.6364 | 3.5 | - |
| **Interesting** | 3.8182 | 3.5 | 72 |
| **Plausible** | 3.1818 | 3.5 | 27 |
| **Engaging** | 3.5455 | 3.25 | 67 |
| **Surprising** | 2.7273 | 2.75 | 48 |
| **Fascinating** | 3.0909 | 3.5 | 26 |
| **Varied** | 3.1818 | 3.5 | 34 |
| **Easy to Follow** | 4.5455 | 4.5 | 54 |
| **Creative** | 3 | 3.5 | 20 |

Table B.10: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with prior video-gaming experience.

| Females, Easy to Follow ($\geq 4$) | | | |
|---|---|---|---|
| $N_A$: 24, $N_S$: 31 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.4167 | 3.0645 | 91 |
| **Agency** | 4 | 3.6452 | 87 |
| **Replay Value** | 3.4583 | 3.2903 | 68 |
| **Gaming Experience** | 1.4167 | 1.6129 | 22 |
| **Interesting** | 3.7083 | 3.7097 | 49 |
| **Plausible** | 3.5 | 3.3871 | 69 |
| **Engaging** | 3.7083 | 3.5806 | 66 |
| **Surprising** | 2.75 | 2.8387 | 38 |
| **Fascinating** | 3 | 2.9677 | 54 |
| **Varied** | 3.4583 | 3.3548 | 63 |
| **Easy to Follow** | 4.875 | 4.7097 | - |
| **Creative** | 3.3333 | 3.129 | 72 |

Table B.11: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players who rated the game as being easy to follow.

| Males, Easy to Follow ($\geq 4$) | | | |
|---|---|---|---|
| $N_A$: 10, $N_S$: 5 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.1 | 3 | 57 |
| **Agency** | 3.3 | 3.6 | 33 |
| **Replay Value** | 3 | 3 | 50 |
| **Gaming Experience** | 3.8 | 3 | 84 |
| **Interesting** | 3.9 | 3.6 | 72 |
| **Plausible** | 3.2 | 3.4 | 34 |
| **Engaging** | 3.7 | 3.4 | 70 |
| **Surprising** | 2.8 | 2.4 | 69 |
| **Fascinating** | 3.1 | 3.2 | 43 |
| **Varied** | 3.2 | 3.4 | 39 |
| **Easy to Follow** | 4.7 | 4.6 | - |
| **Creative** | 3.1 | 3.4 | 28 |

Table B.12: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players who rated the game as being easy to follow.

| Easy to Follow ($\geq 4$), Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 24, $N_S$: 27 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.4583 | 3.037 | 94 |
| **Agency** | 4.0833 | 3.6667 | 91 |
| **Replay Value** | 3.5417 | 3.2222 | 82 |
| **Gaming Experience** | 1.25 | 1.1852 | - |
| **Interesting** | 3.875 | 3.6667 | 76 |
| **Plausible** | 3.5 | 3.4074 | 66 |
| **Engaging** | 3.7083 | 3.6667 | 55 |
| **Surprising** | 2.6667 | 2.8148 | 32 |
| **Fascinating** | 3.125 | 2.8889 | 77 |
| **Varied** | 3.5 | 3.4444 | 57 |
| **Easy to Follow** | 4.7917 | 4.7407 | - |
| **Creative** | 3.375 | 3.2593 | 63 |

Table B.13: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience who rated the game as being easy to follow.

| Easy to Follow ($\geq 4$), Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 17, $N_S$: 15 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2353 | 3 | 76 |
| **Agency** | 3.6471 | 3.5333 | 60 |
| **Replay Value** | 3.1176 | 3.2667 | 36 |
| **Gaming Experience** | 3.4118 | 3.0667 | - |
| **Interesting** | 3.6471 | 3.7333 | 39 |
| **Plausible** | 3.4118 | 3.4 | 51 |
| **Engaging** | 3.7647 | 3.0667 | 96 |
| **Surprising** | 2.8235 | 2.6667 | 64 |
| **Fascinating** | 3.1765 | 3.1333 | 54 |
| **Varied** | 3.2353 | 3.2 | 53 |
| **Easy to Follow** | 4.7059 | 4.6667 | - |
| **Creative** | 3.1765 | 3.1333 | 54 |

Table B.14: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience who rated the game as being easy to follow.

| Females, Easy to Follow ($\geq 4$), Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 21, $N_S$: 25 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.4286 | 3.04 | 91 |
| **Agency** | 4.0952 | 3.68 | 89 |
| **Replay Value** | 3.5714 | 3.24 | 81 |
| **Gaming Experience** | 1.1429 | 1.16 | - |
| **Interesting** | 3.8095 | 3.68 | 65 |
| **Plausible** | 3.5238 | 3.4 | 70 |
| **Engaging** | 3.6667 | 3.76 | 38 |
| **Surprising** | 2.7143 | 2.88 | 31 |
| **Fascinating** | 3.0476 | 2.88 | 69 |
| **Varied** | 3.5238 | 3.44 | 60 |
| **Easy to Follow** | 4.8571 | 4.72 | - |
| **Creative** | 3.381 | 3.2 | 68 |

Table B.15: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience who rated the game as being easy to follow.

| Females, Easy to Follow ($\geq 4$), Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 6, $N_S$: 10 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.6667 | 3 | 91 |
| **Agency** | 4.1667 | 3.5 | 84 |
| **Replay Value** | 3.5 | 3.4 | 55 |
| **Gaming Experience** | 2.6667 | 2.9 | - |
| **Interesting** | 3.5 | 3.8 | 27 |
| **Plausible** | 3.6667 | 3.3 | 79 |
| **Engaging** | 4 | 3 | 93 |
| **Surprising** | 2.6667 | 2.6 | 54 |
| **Fascinating** | 3.1667 | 2.9 | 69 |
| **Varied** | 3.5 | 3 | 79 |
| **Easy to Follow** | 4.8333 | 4.7 | - |
| **Creative** | 3.3333 | 2.8 | 79 |

Table B.16: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience who rated the game as being easy to follow.

| Males, Easy to Follow ($\geq 4$), Mid-Low Experience ($\leq 3$) | | | |
|---|---|---|---|
| $N_A$: 4, $N_S$: 2 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.75 | 3 | 82 |
| **Agency** | 4 | 3.5 | 74 |
| **Replay Value** | 3.5 | 3 | 68 |
| **Gaming Experience** | 2.25 | 1.5 | - |
| **Interesting** | 4.5 | 3.5 | 93 |
| **Plausible** | 3.5 | 3.5 | 50 |
| **Engaging** | 4 | 2.5 | 91 |
| **Surprising** | 2.75 | 2 | 70 |
| **Fascinating** | 3.75 | 3 | 72 |
| **Varied** | 3.5 | 3.5 | 50 |
| **Easy to Follow** | 4.5 | 5 | - |
| **Creative** | 3.5 | 4 | 27 |

Table B.17: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with low prior video-gaming experience who rated the game as being easy to follow.

| Males, Easy to Follow ($\geq 4$), Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 10, $N_S$: 4 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.1 | 2.75 | 73 |
| **Agency** | 3.3 | 3.5 | 39 |
| **Replay Value** | 3 | 2.75 | 68 |
| **Gaming Experience** | 3.8 | 3.5 | - |
| **Interesting** | 3.9 | 3.5 | 76 |
| **Plausible** | 3.2 | 3.5 | 29 |
| **Engaging** | 3.7 | 3.25 | 76 |
| **Surprising** | 2.8 | 2.75 | 52 |
| **Fascinating** | 3.1 | 3.5 | 28 |
| **Varied** | 3.2 | 3.5 | 35 |
| **Easy to Follow** | 4.7 | 4.5 | - |
| **Creative** | 3.1 | 3.5 | 25 |

Table B.18: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on male players with prior video-gaming experience who rated the game as being easy to follow.

# Appendix C

# Detailed Evaluation Results: Stage 2

As mentioned in Section 5.8, confidence values are omitted for metrics whose values were used to select the subset of players being considered.

| All Players | | | |
|---|---|---|---|
| $N_A$: 50, $N_S$: 51 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.16 | 3.0392 | 73 |
| **Agency** | 3.74 | 3.5882 | 74 |
| **Replay Value** | 3.1 | 3.1765 | 37 |
| **Gaming Experience** | 2.12 | 1.902 | 78 |
| **Interesting** | 3.58 | 3.7059 | 27 |
| **Plausible** | 3.32 | 3.3333 | 46 |
| **Engaging** | 3.5 | 3.451 | 58 |
| **Surprising** | 2.8 | 2.8235 | 45 |
| **Fascinating** | 2.98 | 3.0588 | 35 |
| **Varied** | 3.36 | 3.4706 | 31 |
| **Easy to Follow** | 4.36 | 4.451 | 31 |
| **Creative** | 3.16 | 3.2941 | 28 |

Table C.1: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively.

| Easy to Follow ($\geq 4$) | | | |
|---|---|---|---|
| $N_A$: 41, $N_S$: 45 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2195 | 3 | 85 |
| **Agency** | 3.7317 | 3.5556 | 75 |
| **Replay Value** | 3.1463 | 3.1778 | 45 |
| **Gaming Experience** | 2.3171 | 1.9778 | 86 |
| **Interesting** | 3.6098 | 3.7111 | 32 |
| **Plausible** | 3.439 | 3.3778 | 63 |
| **Engaging** | 3.561 | 3.4889 | 62 |
| **Surprising** | 2.7561 | 2.7333 | 53 |
| **Fascinating** | 2.9756 | 3.0222 | 41 |
| **Varied** | 3.3659 | 3.4444 | 37 |
| **Easy to Follow** | 4.7805 | 4.6889 | - |
| **Creative** | 3.1707 | 3.2222 | 41 |

Table C.2: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players who rated the game as being easy to follow.

| Females | | | |
|---|---|---|---|
| $N_A$: 38, $N_S$: 44 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2105 | 3 | 83 |
| **Agency** | 3.8421 | 3.5682 | 85 |
| **Replay Value** | 3.1579 | 3.1591 | 49 |
| **Gaming Experience** | 1.6316 | 1.7727 | 29 |
| **Interesting** | 3.5526 | 3.7273 | 22 |
| **Plausible** | 3.3421 | 3.3182 | 55 |
| **Engaging** | 3.5 | 3.5 | 50 |
| **Surprising** | 2.7895 | 2.8636 | 37 |
| **Fascinating** | 2.9211 | 3.0455 | 29 |
| **Varied** | 3.4474 | 3.4773 | 45 |
| **Easy to Follow** | 4.3158 | 4.4545 | 25 |
| **Creative** | 3.2105 | 3.2273 | 47 |

Table C.3: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players.

| Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 36, $N_S$: 35 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.25 | 3.0571 | 80 |
| **Agency** | 3.9444 | 3.6571 | 88 |
| **Replay Value** | 3.25 | 3.1429 | 64 |
| **Gaming Experience** | 1.2778 | 1.1429 | - |
| **Interesting** | 3.6667 | 3.7143 | 42 |
| **Plausible** | 3.3056 | 3.2857 | 54 |
| **Engaging** | 3.5 | 3.5143 | 47 |
| **Surprising** | 2.75 | 2.8857 | 30 |
| **Fascinating** | 3.0278 | 2.9429 | 62 |
| **Varied** | 3.4722 | 3.5143 | 43 |
| **Easy to Follow** | 4.1667 | 4.3714 | 19 |
| **Creative** | 3.25 | 3.3714 | 33 |

Table C.4: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience.

| Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 24, $N_S$: 21 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.0833 | 2.9048 | 73 |
| **Agency** | 3.5417 | 3.4286 | 62 |
| **Replay Value** | 2.8333 | 3.1905 | 15 |
| **Gaming Experience** | 3.3333 | 3.1905 | - |
| **Interesting** | 3.4583 | 3.6667 | 24 |
| **Plausible** | 3.4167 | 3.4286 | 48 |
| **Engaging** | 3.3333 | 3.1905 | 65 |
| **Surprising** | 2.6667 | 2.6667 | 50 |
| **Fascinating** | 2.9583 | 3.1429 | 27 |
| **Varied** | 3.25 | 3.3333 | 40 |
| **Easy to Follow** | 4.5 | 4.6667 | 24 |
| **Creative** | 2.875 | 3.1429 | 21 |

Table C.5: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience.

| Females, Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 32, $N_S$: 32 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2188 | 3.0312 | 78 |
| **Agency** | 3.9375 | 3.6562 | 85 |
| **Replay Value** | 3.25 | 3.125 | 65 |
| **Gaming Experience** | 1.1875 | 1.125 | - |
| **Interesting** | 3.625 | 3.75 | 32 |
| **Plausible** | 3.3125 | 3.2812 | 56 |
| **Engaging** | 3.5 | 3.625 | 33 |
| **Surprising** | 2.8125 | 2.9375 | 32 |
| **Fascinating** | 2.9688 | 2.9688 | 50 |
| **Varied** | 3.5 | 3.5312 | 45 |
| **Easy to Follow** | 4.1875 | 4.375 | 23 |
| **Creative** | 3.2812 | 3.3125 | 46 |

Table C.6: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience.

| Females, Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 12, $N_S$: 16 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.1667 | 2.875 | 77 |
| **Agency** | 3.6667 | 3.375 | 71 |
| **Replay Value** | 2.75 | 3.25 | 17 |
| **Gaming Experience** | 3 | 3.125 | - |
| **Interesting** | 3.25 | 3.6875 | 14 |
| **Plausible** | 3.5833 | 3.375 | 74 |
| **Engaging** | 3.1667 | 3.1875 | 48 |
| **Surprising** | 2.5 | 2.625 | 37 |
| **Fascinating** | 2.75 | 3 | 25 |
| **Varied** | 3.4167 | 3.25 | 64 |
| **Easy to Follow** | 4.5 | 4.6875 | 29 |
| **Creative** | 2.75 | 2.9375 | 33 |

Table C.7: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience.

| Females, Easy to Follow ($\geq 4$) | | | |
|---|---|---|---|
| $N_A$: 30, $N_S$: 39 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.3 | 2.9744 | 91 |
| **Agency** | 3.8667 | 3.5385 | 86 |
| **Replay Value** | 3.2333 | 3.1795 | 56 |
| **Gaming Experience** | 1.7667 | 1.8205 | 42 |
| **Interesting** | 3.5667 | 3.7179 | 28 |
| **Plausible** | 3.5 | 3.359 | 77 |
| **Engaging** | 3.5333 | 3.5128 | 53 |
| **Surprising** | 2.7 | 2.7692 | 39 |
| **Fascinating** | 2.9 | 2.9744 | 38 |
| **Varied** | 3.4667 | 3.4359 | 54 |
| **Easy to Follow** | 4.8333 | 4.6923 | - |
| **Creative** | 3.2 | 3.1538 | 56 |

Table C.8: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players who rated the game as being easy to follow.

| Easy to Follow ($\geq 4$), Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 27, $N_S$: 30 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.3704 | 3.0333 | 91 |
| **Agency** | 4 | 3.6667 | 87 |
| **Replay Value** | 3.3704 | 3.1667 | 72 |
| **Gaming Experience** | 1.2963 | 1.1667 | - |
| **Interesting** | 3.7407 | 3.7333 | 51 |
| **Plausible** | 3.4815 | 3.3667 | 72 |
| **Engaging** | 3.5926 | 3.6333 | 44 |
| **Surprising** | 2.6667 | 2.8 | 33 |
| **Fascinating** | 3.037 | 2.9 | 68 |
| **Varied** | 3.5185 | 3.5 | 52 |
| **Easy to Follow** | 4.7407 | 4.6667 | - |
| **Creative** | 3.2963 | 3.3 | 49 |

Table C.9: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with low prior video-gaming experience who rated the game as being easy to follow.

| Easy to Follow ($\geq 4$), Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 22, $N_S$: 20 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.1364 | 2.85 | 83 |
| **Agency** | 3.5 | 3.35 | 65 |
| **Replay Value** | 2.8636 | 3.15 | 22 |
| **Gaming Experience** | 3.4545 | 3.2 | - |
| **Interesting** | 3.4545 | 3.65 | 27 |
| **Plausible** | 3.4545 | 3.4 | 58 |
| **Engaging** | 3.5 | 3.1 | 87 |
| **Surprising** | 2.6818 | 2.6 | 59 |
| **Fascinating** | 3 | 3.1 | 37 |
| **Varied** | 3.2727 | 3.3 | 47 |
| **Easy to Follow** | 4.7273 | 4.75 | - |
| **Creative** | 3 | 3.1 | 38 |

Table C.10: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on players with prior video-gaming experience who rated the game as being easy to follow.

| Females, Easy to Follow ($\geq 4$), Low Experience ($\leq 2$) | | | |
|---|---|---|---|
| $N_A$: 24, $N_S$: 28 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.3333 | 3.0357 | 86 |
| **Agency** | 4 | 3.6786 | 84 |
| **Replay Value** | 3.375 | 3.1786 | 70 |
| **Gaming Experience** | 1.2083 | 1.1429 | - |
| **Interesting** | 3.6667 | 3.75 | 39 |
| **Plausible** | 3.5 | 3.3571 | 75 |
| **Engaging** | 3.5417 | 3.7143 | 28 |
| **Surprising** | 2.7083 | 2.8571 | 32 |
| **Fascinating** | 2.9583 | 2.8929 | 58 |
| **Varied** | 3.5417 | 3.5 | 55 |
| **Easy to Follow** | 4.7917 | 4.6429 | - |
| **Creative** | 3.2917 | 3.25 | 54 |

Table C.11: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with low prior video-gaming experience who rated the game as being easy to follow.

| Females, Easy to Follow ($\geq 4$), Experienced ($\geq 2$) | | | |
|---|---|---|---|
| $N_A$: 11, $N_S$: 15 | **Adaptive** | **Static** | **% Confidence** |
| **Fun** | 3.2727 | 2.8 | 88 |
| **Agency** | 3.6364 | 3.2667 | 75 |
| **Replay Value** | 2.8182 | 3.2 | 24 |
| **Gaming Experience** | 3.0909 | 3.1333 | - |
| **Interesting** | 3.1818 | 3.6667 | 13 |
| **Plausible** | 3.6364 | 3.3333 | 82 |
| **Engaging** | 3.3636 | 3.0667 | 72 |
| **Surprising** | 2.4545 | 2.5333 | 42 |
| **Fascinating** | 2.8182 | 2.9333 | 38 |
| **Varied** | 3.4545 | 3.2 | 70 |
| **Easy to Follow** | 4.8182 | 4.8 | - |
| **Creative** | 2.9091 | 2.8667 | 53 |

Table C.12: Average ratings for Adaptive and Static stories, and percent confidence in the Adaptive averages being greater than the Static averages. $N_A$ and $N_S$ represent the numbers of players who played through the Adaptive and Static stories, respectively. Focus on female players with prior video-gaming experience who rated the game as being easy to follow.